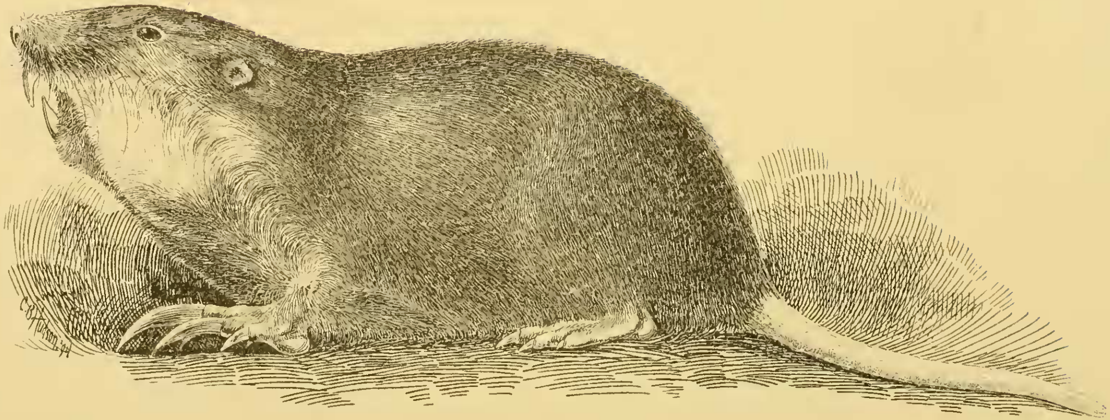

GEORGIA POCKET GOPHER, GEOMYS TUZA (Ord) TYPE OF THE GENUS GEOMYS

U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF ORNITHOLOGY AND MAMMALOGY

NORTH AMERICAN FAUNA

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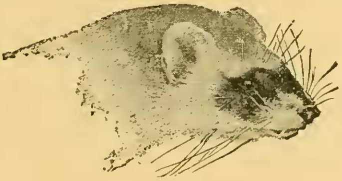

MONOGRAPHIC REVISION OF THE POCKET GOPHERS

Family GEOMYIDÆ

(Exclusive of the species of *Thomomys*)

BY

Dr. C. HART MERRIAM

WASHINGTON

GOVERNMENT PRINTING OFFICE

1895

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 26, 1894.

SIR: I have the honor to transmit herewith, as No. 8 of North American Fauna, a Monographic Revision of the Family *Geomyidæ*, exclusive of the species of *Thomomys*.

In preparing a bulletin on the economic relations of the Pocket Gophers it became necessary to determine the status and geographic distribution of the various forms. This study developed the fact that the group was sorely in need of technical revision. The present paper is the outgrowth of an attempt at such a revision. It has grown so far beyond the limits originally intended that a large genus (*Thomomys*) has been of necessity omitted and will form the subject of a subsequent paper.

The results of the economic study of the group will appear as a separate bulletin prepared by my assistant, Mr. Vernon Bailey.

Respectfully,

C. HART MERRIAM,
Chief of Division of
Ornithology and Mammalogy.

HON. CHAS. W. DABNEY, Jr.,
Acting Secretary of Agriculture.

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No. 8. NORTH AMERICAN FAUNA. January, 1895.

REVISION OF THE POCKET GOPHERS, FAMILY GEOMYIDÆ, EXCLUSIVE OF THE SPECIES OF THOMOMYS.

By Dr. C. Hart Merriam.

INTRODUCTION.

The present paper is based on a study of the rich collection of Pocket Gophers belonging to the U. S. Department of Agriculture, comprising upwards of 800 specimens, exclusive of the genus *Thomomys.* This material has been supplemented by 110 specimens from my private collection, and a number from the U. S. National Museum,* making a total of about a thousand specimens, among which are by far the greater number of actual types known to be extant. The Department collection contains no less than 200 specimens from Mexico, most of which were secured by Mr. E. W. Nelson, a field naturalist of the Division. These, together with a few highly interesting specimens from Costa Rica and Guatemala in the U. S. National Museum, have enabled me not only to bring together for actual comparison all of the species previously described, and to add a considerable number heretofore unknown, but also to recognize several marked generic types whose existence had not been suspected.

Critical study of this unparalleled wealth of material has led to the discovery of some very remarkable dental peculiarities that have been deemed worthy of detailed description and illustration. Moreover, the opportunity has been utilized to contribute a chapter on the morphology of the skull, which it is hoped will prove of service to those interested in the craniology of the Rodentia.

It is a matter of deep regret that the magnificent series of specimens of living forms on which the present paper is based, has not been supplemented by a single fossil; and it is earnestly hoped that an opportunity may yet be found to study the remains of the extinct animals that have been referred to the family—correctly or otherwise—in comparison with the rich collection of living types now in our National Museum. If the theory is correct, that the group has attained its greatest expansion in the present age, we need not look to the rocks

*Placed at my disposal by the courtesy of Mr. F. W. True, Curator of Mammals.

for additional highly diversified types, but only for the links that bind the several phyla together and connect them with the more primitive forms from which they came. These would be of the utmost interest.

The author is indebted to Mr. F. W. True, Curator of Mammals in the U. S. National Museum, for the privilege of describing two species from Central America; to Dr. J. A. Allen, of the American Museum of Natural History, New York, for the privilege of examining the type of his *Geomys cherriei;* and to Mr. H. P. Attwater, of San Antonio, Texas, for the loan of a large series of the subspecies here described as *Geomys breviceps attwateri.* The author is under special obligations to Mr. Oldfield Thomas, Curator of Mammals in the British Museum, and to Dr. Paul Matschie, of the Royal Museum of Natural History in Berlin. Mr. Thomas has kindly compared specimens sent him for that purpose with his own types in the British Museum, and has also contributed measurements and other details of importance. Dr. Matschie has been good enough to remeasure the original types of Peters' *Geomys heterodus* and Lichtenstein's *Geomys mexicanus*, which specimens are still extant in the Berlin Museum, and has further taken the trouble to prepare and send me a table of cranial measurements of the skulls of these same types, with much other information of importance respecting them. And Dr. F. A. Jentink, the able director of the Leiden Museum, has done me the favor to send additional particulars about the Bullock specimen of *Geomys bursarius*, still extant in the Leiden Museum, which specimen has given rise to much controversy and is supposed to be Shaw's original type of the species.

From time to time during the preparation of the work, collectors have been sent to special localities from which new or supplemental material was desired, thus making it possible to settle many points that were originally in doubt. Much has been learned respecting the habits and mode of life of the animals from a living *Geomys lutescens* sent from Vernon, Texas, by my field assistant, Mr. J. Alden Loring. This animal was kept in confinement until sufficiently tame to permit handling freely and was the means of the discovery of a surprisingly large number of interesting facts that otherwise would have escaped detection.

Respecting the illustrations, the frontispiece was drawn by Mr. C. B. Hudson; plate 1 by Mr. Benjamin Mortimer; text figures 1 and 2 by Dr. George Marx; figures 5, 19, 63, 65, and 66 by Dr. James E. McConnell; and all of the outline camera lucida drawings of teeth by myself. Plates 2 to 19, inclusive, and all of the remaining text figures were drawn under my constant supervision by Mr. F. Müller. All of the twenty full-page plates have been reproduced by photolithography by Mr. Berthold Meisel, of Boston, and the text figures, with two or three exceptions, have been electrotyped from the originals by Mr. Harry C. Jones, of New York.

It will be observed that the generic names engraved on most of the plates (pls. 2–6, 8, and 10–16) do not agree with the generic names in the text. This misfortune is the result of having the plates printed before

the genera were finally segregated. The correct names are given in all cases on the explanations facing the plates.

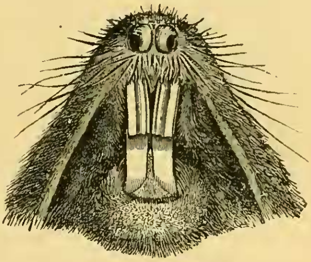
The literature relating to the group is rarely referred to in the present paper, except for original descriptions. The reason is that previous papers have been based on insufficient material. To use them at all would necessitate a large amount of explanation and criticism without corresponding advantage.

All the measurements in the present paper are in millimeters.

CHAPTER I.

GENERAL REMARKS.

The family *Geomyidæ*, comprising the mammals commonly known as Pocket Gophers, is confined to North America, where it ranges from the plains of the Saskatchewan in Canada southward to Costa Rica. It attains its highest development in the western United States and Mexico, and does not inhabit the region east of the Mississippi Valley except in the Gulf States, where it reaches the Atlantic coast in Florida and Georgia, but does not occur north of the Savannah River.



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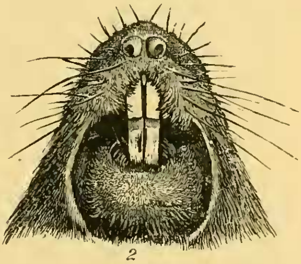

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FIG. 1.—Face of *Geomys bursarius*, showing grooved upper incisors and openings of cheek pouches.

FIG. 2.—Face of *Thomomys talpoides*, showing plane upper incisors and openings of cheek pouches.

The appearance of a characteristic species is well shown in the frontispiece, and the peculiar aspect of the face in the accompanying cut (figs. 1 and 2), which shows the openings of the cheek pouches, wholly outside of the mouth, and also the pattern of the upper incisor teeth in two of the commonest genera, *Geomys* and *Thomomys*.

All the members of the family spend their entire lives underground, and their whole organization is modified in accordance with the needs of a subterranean existence. The species, though numerous, are very much alike externally. They are short-legged, thickset animals, without an appreciable neck, without noticeable external ears, and with very small eyes. The feet are largely developed for digging. The fore paws in particular are very strong, are armed with long curved claws,* and the sides of the toes are lined with rows of bristles that evidently serve in preventing the dirt from

*The relative development of the claws is largely a matter of age and soil. They continue to increase in size throughout the life of the individual; their points are worn off in hard soil so that the claws become thick and blunt. In sandy soil they do not meet enough resistance to produce the usual wear, and, consequently, are longer and more slender than normal.

passing between the fingers (fig. 3), thus completing a more effective arrangement for keeping the tunnels clean, and for pushing the earth out of the openings in the burrows. The tail, which is of moderate length, is thick, fleshy, and usually devoid of hair, and is endowed with tactile sensibility.

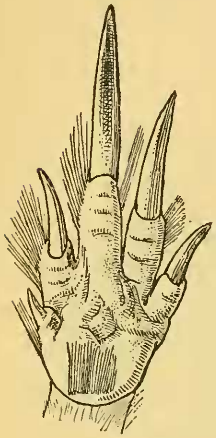


FIG. 3.—Left fore foot of *Geomys personatus*, showing the rows of bristles which form brushes on the sides of the toes.

The Pocket Gophers, in working their way through the earth in the construction of their tunnels, use the powerful upper incisors as a pick to loosen the ground. At the same time the fore feet are kept in active operation, both in digging and in pressing the earth back under the body, and the hind feet are used also in moving it still further backward. When a sufficient quantity has accumulated behind the animal, he immediately turns in the burrow and by bringing the wrists together under the chin, with the palms of the hands held vertically, forces himself along by the hind feet, pushing the earth out in front. When an opening in the tunnel is reached the earth is discharged through it, forming a little hillock that resembles in a general way the hills thrown up by moles. In many species there is a naked callosity or 'nasal pad' over the anterior half of the nose, which must be of great assistance in the construction of the tunnels. When this callosity is largely developed the nasal bones underneath are highly arched or inflated, as in *Heterogeomys hispidus*.

PROGRESSION BACKWARD AS WELL AS FORWARD.

The *Geomys lutescens* already mentioned from Vernon, Texas, which I kept alive for several months, surprised me very much by running backward as rapidly and easily as forward. This method of progression was particularly noticeable when the animal was in his own quarters where he could follow a runway or an accustomed route. When carrying food to one of his storehouses he rarely turned around, but usually ran backward to the place of deposit, returning for more, and repeating the operation again and again, the to-and-fro movement suggesting a shuttle on its track. The well-known peculiarity of the external genitalia, which are so hidden and modified that the sexes are determined with difficulty, is doubtless the result of this habit, protecting the parts from injury when the animal is moving backward.

THE TAIL AN ORGAN OF TOUCH.

Throughout the family *Geomyidæ* the tail is rather large and fleshy, and as a rule is naked or scantily haired;* it varies in length in the

* The tail is naked in most of the southern species and is more or less covered with hair in the northern species. The latter have much more hair on the tail in winter than in summer.

various species from about 65 to 115 mm. The function of this peculiar appendage had long puzzled me, but by watching the live *Geomys* above mentioned as it ran backward in its runways I saw that it was used as an organ of touch. It is doubtless endowed with special tactile sensibility and is evidently of great value in warning the animals of the presence of an enemy in the rear when they are traveling backward in their dark tunnels. So far as I am aware this is the only instance in which the tail of a mammal is used for this purpose.

POSITION OF THE FORE FEET.

In walking on soft ground the fore feet are usually held in the normal position, with the soles down, or inclined slightly inward. In walking on hard ground, however, the fore feet are turned sideways, their soles facing one another, so that the claws curve inward, and the animal walks on the outer or ulnar side of the foot. This method of using the fore foot in walking on hard substances was frequently observed, and enables the animal to walk comfortably where the long curved claws would be in the way if held in the normal position. It was also frequently noticed that the feet were held in the same position (horizontally) when at rest, and when used as a scoop in pushing loads of earth or sand out of the way. When thus engaged the feet were drawn back under the breast, the wrists near together and the long claws turned outward. By moving the body quickly forward the animal always succeeded in throwing ahead of it a considerable quantity of loose earth.

DIVISION OF THE MOUTH INTO TWO CHAMBERS.

The lips and thin furry covering of skin are drawn into the broad space between the incisors and molars, where they meet in a raphe on the roof of the mouth and then separate again to meet around the under jaw, forming a diaphragm-like partition between the incisors and molars. The orifice is small and wholly inferior, and may be completely closed by the fleshy tongue or by the falling together of the furry lips, leaving a vertical slit between. The raphe or line of union of the lips on the roof of the mouth reaches most of the way from the incisors to the upper premolars. A narrow band, not covered with fur, connects the two lips inferiorly, crossing the floor of the mouth near the posterior end of the symphysis of the mandible. Thence the lips—if the term lips may be applied to this fold of skin—pass around the lower incisors, where the skin is attached posteriorly, so that it may be retracted, leaving a bare space below the point where the tooth protrudes from the alveolus, thus giving greater freedom to the lower incisors during the act of gnawing. During the to-and-fro drill-like motion of the jaw the skin probably remains nearly stationary, while the under incisors play rapidly back and forth. The object of the dia-

phragm-like partition which separates the mouth into two chambers is obviously to prevent dirt and chips from entering the mouth proper during the various subterranean operations of the animal.

THE TONGUE.

The tongue is short, thick, and fleshy. Its principal function doubtless is to keep the food between the crowns of the teeth during mastication. At other times it serves as a plug to stop the opening in the furry diaphragm between the incisors and molars.

THE CHEEK POUCHES.

All of the Pocket Gophers are provided with external cheek pouches, which open on the sides of the face outside of the mouth, and are covered with fur inside. These cheek pouches are used exclusively in carrying food, and not in carting dirt as often erroneously supposed. The animals are great hoarders and carry away to their storehouses vastly more than they consume. The cheek pouches reach back as far as the shoulder and are so attached that they can not be completely everted without rupture of their connections. While the posterior part of the sack is held back by the muscle which stretches thence to the lumbar vertebræ, the skin of the inner side of the pouch, which covers the side of the face below the eye and in front of the ear, may be everted or prolapsed, hanging down as a flap below the corners of the mouth. This is probably what happened in the case of snake fright observed by Dr. A. K. Fisher at Ellis, Kansas, in June, 1893. Dr. Fisher saw a gopher snake (*Pituophis*) about 5 feet in length hunting for breakfast. He says: "Presently the snake glided into a gopher hole. In a few minutes I saw a gopher (*Geomys lutescens*) run out as fast as possible from the other end of the line of hills. I soon caught up to it. It appeared very much frightened, and its cheek pouches were hanging out. The gopher evidently had only scented the snake, for it was apparent that the snake had not seen the mammal, as it came out of the hole by which it entered and glided off deliberately in another direction."

HOW GEOMYS PUTS FOOD INTO ITS CHEEK POUCHES.

A live *Geomys* from Vernon, Texas, has been carefully observed for the purpose of ascertaining how the reserve food is placed in the cheek pouches. The animal soon became sufficiently tame to eat freely from the hand, and was commonly fed bits of potato, of which he was particularly fond. The manner of eating was peculiar and interesting, and showed an ability to use the huge fore feet and claws in a way previously unsuspected. After satisfying the immediate demands of hunger it was his practice to fill one or both cheek pouches. His motions were so swift that it was exceedingly difficult to follow them with sufficient exactness to see just how the operation was performed. If a whole

potato was given him, or a piece too large to go into the pouch, he invariably grasped it between the fore paws and proceeded to pry off a small piece with the long lower incisors. He would then raise himself slightly on his hind legs and hold the fragment between his fore paws while eating, for he usually ate a certain quantity before putting any into the pouches. If small pieces were given him he took them promptly and passed them quickly into the pouches. Some pieces were thus disposed of at once; others were first trimmed by biting off projecting angles. As a rule one pouch was filled at a time, though not always, and the hand of the same side was used to push the food in. The usual course is as follows: A piece of potato, root, or other food is seized between the incisor teeth, and is immediately transferred to the fore paws, which are held in a horizontal position, the tips of the claws curving toward one another. If the food requires reduction in size, the trimming is done while held in this position. The piece is then passed rapidly across the side of the face with a sort of wiping motion which forces it into the open mouth of the pouch. Sometimes a single rapid stroke with one hand is sufficient; at other times both hands are used, particularly if the piece is large. In such cases the long claws of one hand are used to draw down the lower side of the opening, while the food is poked in with the other. It is obviously impossible for the animal to pass food from the mouth to the pouches without the aid of its fore claws.

The most remarkable thing connected with the use of the pouches is the way they are emptied. The fore feet are brought back simultaneously along the sides of the head until they reach a point opposite the hinder end of the pouches; they are then pressed firmly against the head and carried rapidly forward. In this way the contents of the pouches are promptly dumped in front of the animal. Sometimes several strokes are necessary. I am not prepared to say that the animal can not empty the pouches by means of the delicate investing muscles, but I have never seen them emptied in any other way than that here described.

THE FOOD.

The food consists chiefly of roots, tubers, and other rather hard vegetable substances, though grass and the succulent parts of plants are sometimes eaten. In agricultural districts the animals are highly injurious, destroying potatoes and other tubers in large quantities, and gnawing off the roots of fruit trees. In fields of grain and fodder they sometimes do considerable damage by the aggregate area covered by the little mounds of earth thrown up from the tunnels.

COLOR PHASES.

In most species of the *Geomyidæ* two color phases occur, a plumbeous or dusky phase and a chestnut-brown or yellowish-brown phase. The latter varies greatly in the different species—from pale straw color or

buffy ochraceous in *Thomomys perpallidus* of the Colorado and Mohave deserts, to dark liver-brown in *Geomys bursarius* of the Upper Mississippi Valley. Taking the group as a whole, the brown phase is by far the commonest and may be regarded as normal; but in certain species in nearly all the genera the plumbeous phase prevails, as in *Thomomys orizabæ*, *Platygeomys fumosus*, and *Zygogeomys trichopus*—all from southern Mexico. The plumbeous pelage is commonly more or less metallic and sometimes even iridescent. It is rare in the United States species, though common in *Thomomys nevadensis* from central Nevada and *Geomys breviceps* from Louisiana. It has not yet been observed in *Cratogeomys castanops* or *Geomys lutescens*, and the red pelage has not been observed in *Zygogeomys trichopus*. So far as known, only a single color phase occurs in the genera *Heterogeomys* and *Orthogeomys*, both of which are dark seal brown in fresh pelage and a dull faded brown in worn pelage.

Seasonal differences in coloration.—Some of the species vary but little with season, as *Geomys bursarius* from the Upper Mississippi Valley; still even this animal is considerably darker in winter than in summer. Others present two well-marked color phases, according to season. In the latter category are *Geomys lutescens*, *breviceps*, and to a less degree *personatus* also. In *lutescens* the summer pelage differs from the winter in the absence of the dark dorsal band which is usually present from October to April or May, and sometimes even as late as June. Apparently the absence of this stripe in summer specimens is sometimes due to wear, the dark tips of the hairs when worn leaving the pale subapical zone exposed. This can not always be the case, however, since one specimen from Chadron, Nebraska, collected April 30, has the dorsal stripe plumbeous throughout with but a faint trace of the pale subapical zone.

In typical *Geomys breviceps*, and also in specimens from the western limit of the range of the species where it seems to be shading toward *lutescens* and *texensis*, the same thing occurs, though the renewal of the pelage takes place at a somewhat different date. This is very apparent in specimens from Gainesville, in the valley of the Red River in northeastern Texas. A specimen taken August 10 has a broad dark dorsal band, while two specimens taken March 27 and March 29 show no trace of this band except on the head, the back being a uniform reddish brown more or less mixed with dusky.

SEXUAL VARIATION.

Sexual variation is marked throughout the genus and in some species is extraordinary. It may be conveniently discussed under two heads, (1) difference in size; (2) difference in cranial characters.

(1) *Difference in size.*—The females are always considerably smaller than the males; the discrepancy is greater in some species than in others. Reference to the tables of measurements shows that the dif-

ference in total length often amounts to 25 or 30 mm.; in length of tail to 12 or 15 mm.; and in hind foot 3 or 5 mm. The difference in the size of the skull is equally marked, and is well shown in the tables of cranial measurements.

(2) *Difference in cranial characters.**—Independent of the conspicuous differences in size between male and female skulls of the same species from the same locality, other and more important differences exist which not infrequently prove troublesome in identifying specimens, particularly if skulls of both sexes are not at hand for comparison. The female as a rule has the brain case broader and flatter, the zygomata narrower and less angular, the jugal narrower anteriorly, the rostrum and nasals shorter, and the skull as a whole smoother. In other words, the cranium of the female is much less specialized than that of the male and often points suggestively to the stock from which the species was derived. It thus happens in the case of series of species in which the successive forms in the development of a particular type are still extant (as in the *texensis-bursarius* series) that the female resembles the male of the species next below in the line of descent more than the male of her own species.

In several forms in which the males have well developed sagittal crests, the females have a sagittal area bounded by distant temporal impressions; and in species in which the males have prominent temporal ribs, the females commonly have more widely separated temporal impressions which rise as ridges from the outer side but not from the inner side, the interspace being more or less thickened.

INDIVIDUAL VARIATION.

The family *Geomyidæ* presents the usual range of individual variation, both in size and in cranial characters. While the male and female skulls of a species agree very well among themselves, showing strong average characters, there are in every large series one or two skulls which depart from the type in one or more particulars. These departures are most common in the form and manner of ending of the nasals and ascending branches of the premaxilla. In all such cases sexual differences should be carefully eliminated before assuming that the departure is individual.

Individual variation is always more marked in the secondary or accessory cranial structures than in the more important and less variable elements. Thus the peripheral processes and expansions for the attachment of muscles are always more variable than other parts of the skull. The degree of lateral production of the squamosal, and of the angular process of the mandible in *Platygeomys gymnurus*, and the variations in

* The sexual organs are so arranged in the *Geomyidæ* as to be difficult of determination in the flesh, except during the rutting season; hence the sex marks on labels may be safely ignored if they conflict with the cranial characters.

detail of the occipital basin, are illustrations of this kind. Still, in studying large series of skulls of a single species, one is much more deeply impressed by the strong tendency toward the development in each bone of a particular type of form than by the departures therefrom.

The animals continue to grow for several years, so that the majority of breeding individuals are still far from the full size of their species. This is very apparent in the skulls, which not only continue to increase in actual size but also, in many species, in the ratio of zygomatic breadth to length, and in the development of ridges and processes for muscular attachments.

SUBDIVISIONS OF THE FAMILY GEOMYIDÆ.

A superficial examination of the skulls of the various species of *Geomyidæ* is sufficient to show the existence of several widely different types. Heretofore the common practice has been to divide the family into two genera, *Thomomys* and *Geomys*, according to the absence or presence of distinct grooves in the upper incisors, and to subdivide the genus *Geomys* into two series, unisulcate and bisulcate. The number of grooves was believed to be correlated with certain cranial characters, the members of the unisulcate series having widely spreading zygomatic arches, the outer angles of which were broadly expanded, while the bisulcate series had narrower arches and lacked the expansion; but no attempt was made to separate them, even subgenerically. The recent discovery of a large number of new forms in Mexico and Central America, comprising several highly diversified types, renders this classification inadequate. After subtracting the strongly marked genus *Thomomys*, which differs from all the others in numerous important characters heretofore overlooked, a heterogeneous assemblage remains, comprising the animals commonly lumped under the generic name *Geomys*, and also the new forms here first described. Of these, the bisulcate series may be divided into two very distinct and two minor types, while the unisulcate series contains at least six well-marked subdivisions.

In attempting a logical classification of the group, one is met at the outset by the difficulty that some of the specialized or peripheral types are more or less closely connected with the trunk line by existing intermediate forms, making it exceedingly difficult to draw hard and fast lines without unnecessary subdivision. The genus *Geomys* as here restricted is such a case. It comprises two quite distinct branches, *Geomys tuza* and *G. bursarius*, which are connected with one another and with the trunk line, or something very near it, by a series of generalized species, the *texensis-breviceps* series. In cases of this kind two courses are open, either to separate the extreme peripheral forms from the less specialized species leading up to them, or to unite the entire branch under a single genus. The latter course has been followed in the present instance. But each case must be decided on its merits. One that has been treated differently is the large limb whose ends, as now known, are represented by two of Mr. Thomas's species, *bulleri*

and *merriami;* the former is not far removed from the trunk line of the group; the latter is one of the terminal branches. But the two forms differ in cranial and dental characters of great weight, and are furthermore separated by an enormous gap which is not bridged at any point by any of the species yet discovered. For these reasons they are treated as independent genera. Still another reason for this course, if another were needed, is the circumstance that the branch ending in *merriami* is only one of four equally specialized terminal boughs, all apparently springing from and bearing the same relation to the single limb or main stem whose base is marked by *bulleri.*

In dividing the family into genera the aim has been to select as types the most specialized peripheral forms and to assemble around them the less specialized species. A study of the enamel pattern of the molariform teeth shows that the *Geomyidæ* may be divided primarily into five groups, several of which are of supergeneric value, and a study of the fundamental cranial characters leads to the recognition of nine genera. By means of the following brief key, any of the species now known may be easily referred to its proper genus without cutting the skull:

KEY TO GENERA.

(1) NO ENAMEL ON POSTERIOR FACE OF UPPER PREMOLAR.

Posterior enamel plate present on first and second upper molars.
  Upper incisor bisulcate .... *Geomys.*
  Upper incisor unisulcate
    Frontal strongly constricted (biconcave) between orbits ..... *Pappogeomys.*
    Frontal not constricted between orbits; very broad .... **Orthogeomys.*
Posterior enamel plate absent in first and second upper molars.
  Breadth of cranium across squamosals much less than zygomatic breadth; lambdoid crest not sinuous (simply convex posteriorly); angle of mandible short .... *Cratogeomys.*
  Breadth of cranium across squamosals greater than zygomatic breadth; lambdoid crest strongly sinuous; angle of mandible very long .... *Platygeomys.*

(2) ENAMEL PRESENT ON POSTERIOR FACE OF UPPER PREMOLAR.

Posterior enamel plate of upper premolar restricted to inner side.
  Posterior enamel plate present and complete on first and second upper molars.
  Frontal not constricted between orbits; very broad; pterygoids long .... **Orthogeomys.*
  Frontal strongly constricted between orbits; pterygoids short.
    Postorbital process absent; palatopterygoids long and slender (pterygoid part narrow) .... *Heterogeomys.*
    Postorbital process strongly marked; palatopterygoids short and broad (pterygoid part very broad) .... *Macrogeomys.*

**Orthogeomys* presents an exceptional condition of the enamel pattern of the upper premolar. The posterior enamel plate of this tooth is evidently disappearing; it is present on the inner side in *O. latifrons*, but is altogether absent or reduced to a very narrow strip in *O. grandis* and *scalops*.

Posterior enamel plate of upper premolar complete.

Posterior enamel plate present on inner (lingual) side only of first and second upper molars.

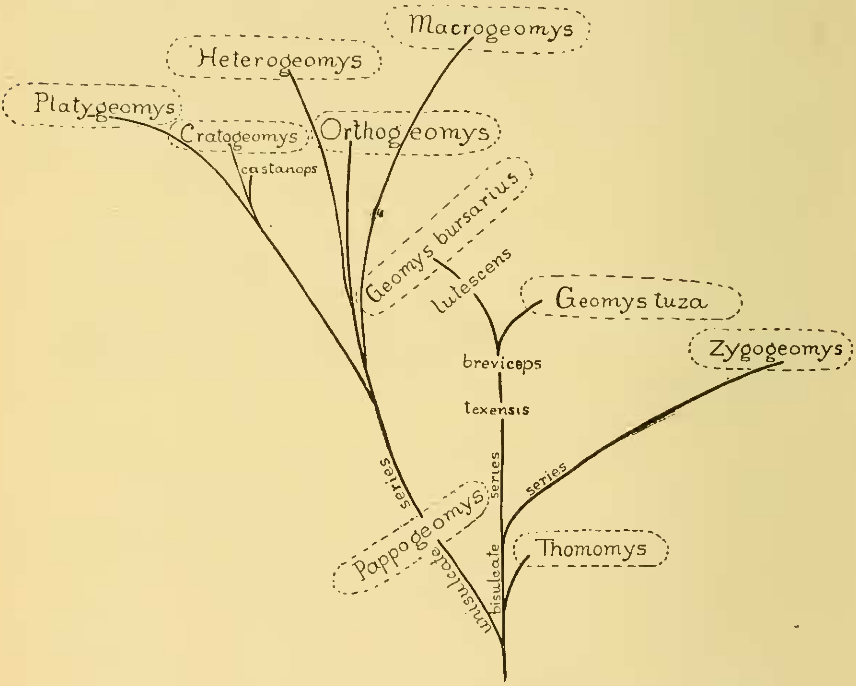
Zygomatic arch complete without jugal (jugal inferior); incisors bisulcate .... *Zygogeomys.*

Posterior enamel plate present and complete on first, second, and third upper molars.

Incisors not grooved, or with a single fine sulcus on inner side.. *Thomomys.*

PHYLOGENETIC TREE OF THE GENERA.

The accompanying phylogenetic tree is intended to represent the author's conception of the interrelations of the nine living genera of



Phylogenetic tree of the Geomyidæ.

the *Geomyidæ* now known. It is introduced with a full knowledge of the modern tendency to disregard and even belittle such attempts; but I am aware of no way in which the results of painstaking research respecting the affinities of organisms may be expressed so graphically. Apparently there were four forks to the early *Paleo-Geomine* phylum: one running into *Thomomys*, another producing the bisulcate series of *Geomys*, beginning with *texensis* or *arenarius* and ending in *bursarius;* the third developing the anomalous bisulcate *Zygogeomys;* the fourth, a strictly unisulcate series, of which *bulleri* and *albinasus* are the least specialized forms now known, splitting into four very distinct branches, each of which now forms a well-marked genus. In the case of the

branch leading up to *Geomys bursarius* the series of living forms is practically complete; in the case of the other branches the connecting links are unknown. It is evident that both *Pappogeomys bulleri* and *Geomys texensis* branched off from points not very remote from the place where *Thomomys* left the trunk line, and that they have undergone relatively little modification since.

The evolution of some types takes place in a very direct way, apparently by uninterrupted progress in a definite direction, and the species comprising such a series, as *texensis*, *breviceps*, *lutescens*, and *bursarius*, may be looked upon as stages in the evolution of the type. The origin of other types is more circuitous and less easily understood. Fortuitous variations lead to the appearance of numerous side branches, most of which abort before developing any very pronounced individuality. Others are more fortunate. Chancing to fit some phase of the environment previously unutilized, they go on until a maximum of departure compatible with the balance of the organism as a whole is attained. There are several of these highly specialized departures from the main stem in the *Geomyidæ*, such as *Cratogeomys*, *Platygeomys*, *Macrogeomys*, and *Zygogeomys*.

LIST OF THE GENERA AND SPECIES.

Genus GEOMYS Rafinesque.

Name of species.	Type locality.
Geomys tuza (Ord)	Augusta, Georgia.
tuza floridanus (Aud. and Bach.)	St. Augustine, Florida.
tuza mobilensis subsp. nov	Mobile Bay, Alabama.
bursarius (Shaw)	Minnesota?
lutescens Merriam	Western Nebraska.
breviceps Baird	Mer Rouge, Louisiana.
breviceps sagittalis subsp. nov	Galveston Bay, Texas.
breviceps attwateri subsp. nov	Rockport, Aransas County, Texas.
texensis sp. nov	Mason, Texas.
arenarius sp. nov	El Paso, Texas.
personatus True	Padre Island, Texas.
personatus fallax subsp. nov	Corpus Christi, Texas.

Genus PAPPOGEOMYS nob.

Pappogeomys bulleri (Thomas)	Talpa, Mascota, Jalisco, Mexico.
albinasus sp. nov	Guadalajara, Jalisco, Mexico.

Genus CRATOGEOMYS nob.

Cratogeomys merriami (Thomas)	Valley of Mexico.
perotensis sp. nov	Cofre de Perote, Mexico.
estor sp. nov	Las Vigas, Vera Cruz, Mexico.
peregrinus sp. nov	Mount Iztaccihuatl, Mexico.
oreocetes sp. nov	Mount Popocatapetl, Mexico.
castanops (Baird)	Las Animas, Colorado.
castanops goldmani subsp. nov	Cañitas, Zacatecas, Mexico.
fulvescens sp. nov	Chalchicomula, Puebla, Mexico.

Genus PLATYGEOMYS nob.

Platygeomys gymnurus Merriam................Zapotlan, Jalisco, Mexico.
tylorhinus sp. nov ....Tula, Hidalgo, Mexico.
planiceps sp. nov................Northern slope Volcan Toluca, Mexico.
fumosus Merriam ....Colima City, Colima, Mexico.

Genus ORTHOGEOMYS nob.

Orthogeomys scalops (Thomas) ....Tehuantepec, Mexico.
grandis (Thomas).............Dueñas, Guatemala.
latifrons sp. nov ....Guatemala.
nelsoni sp. nov. ....Mt. Zempoaltepec, Oaxaca, Mexico.

Genus HETEROGEOMYS nob.

Heterogeomys hispidus (LeConte) ....Near Jalapa, Vera Cruz, Mexico.
torridus sp. nov ....Chichicaxtle, Vera Cruz, Mexico.

Genus MACROGEOMYS nob.

Macrogeomys heterodus (Peters).............Costa Rica.
dolichocephalus sp. nov ....San José, Costa Rica.
costaricensis sp. nov ....Pacuare, Costa Rica.
cherriei (Allen) ....Santa Clara, Costa Rica.

Genus ZYGOGEOMYS nob.

Zygogeomys trichopus sp. nov.................Nahuatzin, Michoacan, Mexico.

GEOGRAPHIC DISTRIBUTION OF THE FAMILY AND GENERA.

The area inhabited by the family *Geomyidæ* stretches from the dry interior of British Columbia and the Plains of the Saskatchewan southward to Costa Rica. In an east and west direction the group covers the continent from ocean to ocean, except that it is absent from the region north of the Savannah River and east of the Mississippi Valley, as shown by the accompanying maps (maps 1, 2, and 3). The group is clearly of Sonoran origin and reaches its highest development on the southern part of the table-land of Mexico. The great majority of the species inhabit the upper and lower Sonoran zones, though a few specially modified forms range upward on favorable mountain sides through the Transition and even into the lower edge of the Boreal zone. On the other hand, two species inhabit the tropical belt of Mexico.

Distribution by genera.—The present distribution of the genera coincides very nicely with their systematic relations.

The genus *Thomomys* (map 1, A) has by far the most extended range of any single genus, inhabitating suitable localities from the valley of Mexico and Mount Orizaba northward to British Columbia and the North Saskatchewan river, and from the Pacific coast eastward to the Great Plains.

The genus *Geomys* (map 1, B and B′) inhabits a broad belt across the middle part of the United States, from the Red River Valley in northwestern Minnesota and northeastern North Dakota southward to the

Mexican boundary along the Rio Grande; and also the southern half of Alabama and Georgia, and the northern half of Florida. The genus does not occur west of eastern Wyoming, east-central Colorado, and the Rio Grande Valley in New Mexico. (See also map 4.)

The genus *Cratogeomys* (map 2) inhabits the Great Plains of the United States from the Arkansas River in eastern Colorado southward, and the eastern table-land region of Mexico to its extreme southern edge in the States of Mexico and Puebla.

The genus *Pappogeomys* (map 3^1) is known only from the State of Jalisco in Mexico.

The genus *Platygeomys* (map 3^2) inhabits a rather narrow belt along the southern border of the Mexican table-land in the States of Jalisco, Colima, Michoacan, Mexico, and Hidalgo.

The genus *Orthogeomys* (map 3^5) inhabits elevated parts of the States of Oaxaca and Chiapas, in extreme southern Mexico and adjacent parts of Guatemala.

The genus *Heterogeomys* (map 3^4) inhabits the tropical plains of Vera Cruz, below the edge of the table-land, and extends thence southerly to Coban in Guatemala, probably following the low coastal plain of Tabasco to the Rio Usumacinta and thence up the valleys of the San Pedro and its tributaries to the interior of Guatemala.*

The genus *Macrogeomys* (map 3^6) inhabits the highlands and mountains of Costa Rica and is not known elsewhere.

The genus *Zygogeomys* (map 3^3) inhabits the Sierra Madre of the State of Michoacan on the southern part of the table-land of Mexico.

NUMBER AND DISTRIBUTION OF THE SPECIES.

Omitting the genus *Thomomys*, the number of species recognized by Baird in 1857 was 7, as follows: *G. bursarius*, *breviceps*, *pinetis* [=*tuza*], *clarkii*, *castanops*, *hispidus*, and *mexicanus*. The number recognized by Coues twenty years later, in 1877, was 5, as follows: *G. bursarius*, *tuza*, *castanops*, *hispidus*, and *mexicanus*. Coues degraded 2 of Baird's species to synonomy, uniting *breviceps* with *bursarius*, and *clarkii* with *castanops*. The same fate overtook *G. heterodus* of Peters, described in the interval between Baird and Coues; it was made a synonym of *hispidus*.

The number of species and subspecies recognized in the present paper is 37, of which 21 are described as new. The remaining 16 are accounted for as follows: Four out of the 5 admitted by Coues are retained, namely, *bursarius*, *tuza*, *castanops*, and *hispidus*, but the fifth, *mexicanus*, is rejected as preoccupied by an unidentifiable species (see

* While this paper is passing through the press, a specimen of *Heterogeomys* has been received from Mr. Nelson, collected by him at Reyes, about 50 miles north of the city of Oaxaca, in the State of the same name, and 33 miles south of the boundary of Vera Cruz and Puebla.

postea, p. 200). Baird's *breviceps* and Peters's *heterodus* are reinstated as valid species, and *floridanus* of Audubon and Bachman is admitted as a subspecies of *tuza*. The remaining 9 have been described since the publication of Coues's Monograph—in fact, during the past five years—and no less than 6 of them are from Mexico and Guatemala. These species are: *personatus* of True; *bulleri*,* *grandis*, *scalops*, and *merriami* of Thomas; *lutescens*, *fumosus*, and *gymnurus* of Merriam, and *cherriei* of Allen. Of the 21 new forms here described, 6 are from the southern United States (1 from Alabama and 5 from Texas), 12 from southern Mexico. 2 from Costa Rica, and 1 from Guatemala. Of the total number here recognized (37), 10 are restricted to the United States; 2 (probably 3†) are common to the United States and northern México; 17 are restricted to the southern half of Mexico; 2 are common to southeastern Mexico and adjacent parts of Guatemala, and 5 are known from Guatemala and Costa Rica only. Thus no less than 24 species, representing, as will be shown later, 7 distinct groups or genera, are absolutely confined to southern Mexico and northern Central America. The extraordinary and unexpected richness of this part of tropical America in members of the group,‡ and the even more remarkable diversity of structure presented by the various types, are of the utmost interest in view of the time and place of origin of the family to which they belong.

UNITED STATES SPECIES.

The Pocket Gophers of the United States fall naturally into two principal subdivisions, (1) those having the upper incisors deeply marked by a median longitudinal furrow (*unisulcate series*), and (2) those having the upper incisors double grooved, a narrow sulcus on the inner margin of the tooth and a larger and deeper one near the middle (*bisulcate series*). The unisulcate series is represented by a single species, *castanops* of Baird, which inhabits the western plains from middle Colorado southward into Mexico. The members of the bisulcate series inhabit-

* *G. bulleri* was described almost simultaneously by Mr. Thomas and myself, but Mr. Thomas's description was issued first and his name *bulleri* has priority over my name *nelsoni*.

†These are *Geomys arenarius*, which is common on both sides of the Rio Grande at El Paso, Texas, and Juarez, Mexico, and *Cratogeomys castanops*, which inhabits extensive areas in western Texas and Chihuahua. A third species, *Geomys personatus*, inhabits the lower Rio Grande region in Texas and in all probability occurs on the Mexican side also (in the state of Tamaulipas).

‡When it is remembered that only about half a dozen specimens, all told, have been examined from Costa Rica and Guatemala, as compared with 200 from Mexico, it must be evident that the possibilities of Central America have been by no means exhausted. Furthermore, no specimens have been seen from Yucatan, though the family is represented there by at least one species. (Biologia Centrali-Americana, Mammalia, 1880, p. 160.)

ing the United States are 12 in number. These, with their type localities, are as follows:

Geomys tuza (Ord)	Augusta, Georgia.
tuza floridanus Bach.	St. Augustine, Florida.
tuza mobilensis subsp. nov	Mobile Bay, Alabama.
bursarius (Shaw)	Minnesota?.
lutescens Merriam	Birdwood Creek, western Nebraska.
breviceps Baird	Mer Rouge, Louisiana.
breviceps sagittalis subsp. nov	Galveston Bay, Texas.
breviceps attwateri subsp. nov	Rockport, Aransas County, Texas.
texensis sp. nov	Mason, Texas.
arenarius sp. nov	El Paso, Texas.
personatus True	Padre Island, Texas.
personatus fallax subsp. nov	Corpus Christi, Texas.

Geomys bursarius is the common Pocket Gopher of the northern Mississippi Valley, from eastern North Dakota and western Minnesota south to southeastern Missouri. It is a dark liver-colored animal with pure white forefeet, in sharp contrast to the color of the surrounding parts, and has the longest claws of any of the bisulcate species.

Geomys lutescens is a pallid form of the *bursarius* type, inhabiting the arid sand hills of western Nebraska and extreme eastern Wyoming, and ranging thence southerly into northwestern Texas.

Geomys breviceps inhabits the alluvial lands of Louisiana, Arkansas, and eastern Texas, the typical form coming from Prairie Mer Rouge, in Morehouse Parish. It extends thence northwesterly up the valley of the Arkansas River nearly to the Kansas border. It is a rather small dark species. On the south, along the coast region of Texas, it splits up into the two following subspecies:

Geomys breviceps sagittalis inhabits the gulf coast of Texas about Galveston Bay. It is smaller than true *breviceps*.

Geomys breviceps attwateri inhabits the coastal plain and islands of Texas, from Nueces Bay northward to Matagorda Bay, and ranges into the interior nearly to San Antonio. It is considerably larger than typical *breviceps*.

Geomys texensis in its typical form inhabits central Texas. On the north and northwest it probably passes into *lutescens*, while on the east it may intergrade with *breviceps*. It is much smaller than *bursarius* or *lutescens* and has a pure white belly. Its upper parts are reddish-brown, paler than *bursarius*, but darker and brighter than *lutescens*.

Geomys arenarius inhabits a very restricted area in the upper Rio Grande Valley in extreme northern Chihuahua, western Texas, and southern New Mexico. So far as known it is completely isolated, not coming in contact with any other bisulcate species. It is of medium size, has a relatively long tail, and the upper parts are drab.

Geomys personatus inhabits Padre Island and the adjacent coast of Texas from Santa Rosa southward, extending inland as far as Carrizo, on the Rio Grande; its range, together with that of its subspecies *fallax*, thus coincides with the northern arm of the arid tropical belt along the

Gulf coast. In external appearance *personatus* much resembles *G. lutescens* of the Great Plains, from which it may be distinguished at once by its larger size, larger and more naked tail, and by important cranial characters.

Geomys personatus fallax inhabits a small area on the Gulf coast of Texas, immediately south of Nueces Bay. It is smaller and darker than true *personatus*.

Geomys tuza, a rather large cinnamon-brown species, inhabits the pine barrens of eastern Georgia, where it is locally known as the 'Salamander.' The same name is applied to the following subspecies:

Geomys tuza floridanus is a Florida form of *tuza*, as its name indicates, and does not differ materially in external appearance.

Geomys tuza mobilensis inhabits southern Alabama and northwestern Florida and is a strongly marked form. It is very much darker than *tuza*. (For distribution of United States species see map 4).

DISTRIBUTION OF THE MEXICAN SPECIES.

At my request Mr. Nelson has prepared the following note, embodying his personal knowledge of the geographical and vertical distribution of the species obtained by him in Mexico, exclusive of the genus *Thomomys*:

"One of the most remarkable and interesting features connected with the Mexican Pocket Gophers is the small area within which most of the known species occur. This area is a belt about 400 miles in length by 60 in breadth, stretching from the Pacific coast to the Gulf of Mexico, between the nineteenth and twentieth parallels of north latitude. It contains the thirteen highest peaks of Mexico,* all of which attain an altitude of 12,000 feet or upward. The most notable of these are Iztaccihuatl (17,000 feet), Popocatapetl (17,523 feet), and Orizaba (18,314 feet).†

*The only peak in Mexico attaining an altitude exceeding 12,000 feet, in addition to those here enumerated, all of which lie in the *Geomys belt*, is Mount Zempoaltepec, in the State of Oaxaca. This peak is said to reach 12,000 feet, and is inhabited by a new species of gopher here named *Orthogeomys nelsoni*.

†The complete list with approximate altitudes, beginning at the westernmost, is as follows:

	Feet.	
Sierra Nevada de Colima	14,000,	State of Jalisco.
Volcano de Colima	12,000,	Do.
Pico de Tancitaro	12,653,	State of Michoacan
Pico de Patamban	12,290,	Do.
Volcano de Toluca	15,000,	State of Mexico.
Cerro de Ajusco	12,000,	Do.
Popocatapetl	17,523,	State of Puebla.
Iztaccihuatl	17,000,	Do.
Cerro de Telapon	13,575,	Do.
Cerro de Malinche	13,462,	State of Tlaxcala.
Orizaba	18,314,	State of Puebla.
Sierra Negra	15,000,	Do.
Cofre de Perote	14,000,	State of Vera Cruz.

"The main chain of the Cordillera or Sierra Madre extends along this line and forms here the southern limit of the plateau or table-land region. The mountains throughout this district are of volcanic origin. They inclose numerous high valleys, such as that of Toluca (8,600 feet) and the valley of Mexico (7,400 feet). The main body of the range takes the form of high rounded ridges between 7,000 and 9,000 feet in altitude. On the north the ridges slope down to the adjacent tablelands; on the south a longer slope carries their bases into the low hot valleys of the streams that lead out to the sea. The average elevation of the belt under discussion is far greater than that of any other equal area in Mexico or Central America; this belt also contains the only peaks of the region that are permanently capped with snow.

"The characteristic trees of all these mountains are pines, firs, and alders. In descending toward the hot coast country, below 7,000 feet, oaks come in, and as the descent is continued they in turn give way before the subtropical and tropical species. Although most of the area within the limits given is high and cool, yet at each end a sharp descent leads to the low, hot coast country.

"Gophers occur throughout this area, from the hot coast districts up to the scattered vegetation about timber line. *Geomys fumosus*, the extreme westernmost species, burrows in the damp clayey soil among the cocoanut palms about the city of Colima, at an altitude of from 1,000 to 2,500 feet. *Geomys hispidus*, the easternmost representative of the group, inhabits the coffee and sugar-cane fields of Vera Cruz. In the intervening district the other species range from 4,000 feet up to timber line. Although several reach as high as 12,500 or even 13,000 feet, the great majority of individuals of all species occur below 9,000 feet, and a vertical section of the country from 4,000 to 9,000 feet would include all of the species and nearly all of the individuals of the interior forms. By far the greatest development of the group is reached between the altitudes of 6,000 and 8,500 feet. This area is along the lower border of the pine and oak forest and reaches out along the adjacent treeless plains for a short distance. Considered faunally, this area is Upper Sonoran and Transition. The northern base of this part of the Cordillera forms the southern limit of many species of birds and mammals belonging to the great interior deserts of the United States and the plateau of Mexico, while their southern base and adjacent slopes form the northern limit of various tropical species.

"It was observed also that whenever the route led to the north or south of this belt the pocket gophers became rapidly less numerous, and ceased entirely except in a few places.

"By far the greater number of species now known from Mexico are absolutely restricted to limited areas within this district, while others push out only a little beyond.

"The animals, as a group, are generally found in rather loose soil and avoid stony areas. In some cases, as with *G. fumosus*, the soil may be

a tough clay, but this is exceptional. Wherever found in cultivated districts they invade fields, and frequently commit serious damage to crops of both grains and tubers. It is a common practice for the landowners to pay a fixed bounty to their field hands for them. The owner of a hacienda near Atlisco, Puebla, told me he had thus paid for seventy dozen on his hacienda in a single year, at the rate of 6 cents a head."

The most interesting and unexpected result of Mr. Nelson's explorations is the knowledge that the family *Geomyidæ* attains its highest development in a belt about 400 miles in length by 60 in breadth which crosses Mexico from west to east along the southern edge of the tableland. Within this belt Mr. Nelson collected 175 specimens, not counting the genus *Thomomys*. These specimens belong to six different genera and represent 15 species, no less than 12 of which were previously unknown.*

WEIGHT OF CHARACTERS.

Nothing is more difficult, in entering upon the study of a new group, than to determine the relative weight of characters. Structures of known stability in one group may be highly variable in another, so that characters that are of generic value in the one may be of only specific value in the other. In framing genera and higher groups therefore it is desirable to select deep-seated structures and those that are not easily affected by external influences. In the case of the skull, it is convenient to divide the characters into two categories, fundamental or primary, and superficial or secondary. *Fundamental* characters are based on structures and relations that enter into the ground plan of the skull, and are of high morphologic weight; *superficial* characters are the result of special adaptations and particular muscular strains, and are of little value except as affording recognition marks for species, and in some instances for genera also. The fundamental structures are mostly hidden, comprising the floor of the brain case, the craniofacial axis, and the turbinated bones. They are seen to best advantage in vertical longitudinal sections and in skulls from which the vault of the cranium has been removed. On the outside of the skull the palatopterygoid plates, and perhaps the frontals also, may be regarded as belonging to the same category. The superficial structures are those that appear on the outer side of the cranium and are most easily modified by muscular strain, or are the secondary result of dental peculiarities. They comprise the zygomatic arches, muzzle, nasals, occiput, and such parts of

* Since the above note was written—in fact just as this paper is going to press—Mr. Nelson has sent me 15 specimens of large gophers from the State of Oaxaca, in extreme southern Mexico. Ten of these, from Cerro San Felipe, are the species recently described by Mr. Oldfield Thomas as *Geomys scalops;* the remaining 5 are a new species, *Orthogeomys nelsoni*. They were collected at three localities: Mount Zempoaltepec, Totontepec, and Comaltepec. All of the specimens from the State of Oaxaca belong to a genus (here named *Orthogeomys*) quite distinct from any of the genera inhabiting Mr. Nelson's *Geomys* belt.

the outside of the vault of the cranium as are materially altered in form and extent (as the squamosals) without sensibly changing their relations on the inner side of the brain case.

LIST OF SPECIMENS EXAMINED.

Geomys tuza (Ord)	32
tuza floridanus (Aud. and Bach.)	25
tuza mobilensis subsp. nov	23
bursarius (Shaw)	116
lutescens Merriam	136
breviceps Baird	195
breviceps sagittalis subsp. nov.	26
breviceps attwateri subsp. nov.	53
texensis sp. nov	31
arenarius sp. nov	43
personatus True	33
personatus fallax subsp. nov.	22
Pappogeomys bulleri (Thomas)	6
albinasus sp. nov	1
Cratogeomys merriami (Thomas)	31
perotensis sp. nov	13
estor sp. nov	10
peregrinus sp. nov	1
oreocetes sp. nov	1
Cratogeomys castanops (Baird)	43
castanops goldmani subsp. nov	5
fulvescens sp. nov	11
Platygeomys gymnurus Merriam	10
tylorhinus sp. nov	9
planiceps sp. nov	3
fumosus Merriam	11
Orthogeomys scalops (Thomas)	13
nelsoni sp. nov	5
latifrons sp. nov	1
Heterogeomys hispidus (Le Conte)	9
torridus sp. nov	27
Macrogeomys heterodus (Peters)	1
dolichocephalus sp. nov	2
costaricensis sp. nov	1
cherriei (Allen)	1
Zygogeomys trichopus sp. nov	12

CHAPTER II.

MORPHOLOGY OF THE SKULL.

1. THE CRANIUM AS A WHOLE.

While diversity prevails in the form of the cranium as a whole and in a multitude of minor details, all the members of the family *Geomyidæ* agree in the following important characters: The top of the skull is flattened, the nasals, frontals, and parietals usually forming nearly a straight line (though the line is decidedly convex in *Cratogeomys castanops* and *fulvescens*). The *tympanic* or audital bullæ are rather large, and the external meatus is a long tube directed forward as well as outward, and opening externally immediately behind the posterior angle of the zygoma. There is a well-developed *mastoid bulla* which is wholly on the occipital plane, never reaching the top of the skull. The *squamosals* are largely developed, always overlapping the lower part of the parietals and hinder part of the frontals, and sending out posteriorly a lateral arm which enters into the occipital plane and overreaches the mastoid process of the mastoid bulla. They articulate broadly with the alisphenoid, but leave a long slit-like vacuity between the postero-inferior margin and the audital bulla. The *basisphenoid* and *presphenoid* are higher than broad. The former develops air cells in its body; the latter is a thin vertical plate always perforate anteriorly opposite the

sphenoidal fissure, so that in viewing the skull from the side one sees completely through it below the orbitosphenoids. The *alisphenoids* are larger and reach, or nearly reach, the upper surface of the cranium; they are inseparably ankylosed to the basisphenoid before birth. The *orbitosphenoids* are small and horizontal and are not united to the alisphenoids except in *Zygogeomys* and *Thomomys*. The *turbinated bones*, while presenting important differences in the several genera, agree in the following particulars: Anteriorly there is a single *maxillo-turbinal*, always attached to the premaxilla; above and parallel to it is a large *naso-turbinal*, always attached to the nasal; posteriorly, and attached to the cribriform plate and os planum are the *endoturbinals* (of Harrison Allen), always four in number and always decreasing in size from above downward; the uppermost is expanded anteriorly.

The *bony palate* is long and narrow, broader posteriorly than anteriorly, and composed chiefly of the *maxilla*, the body of the *palatine* being relatively small and situated far back. There is a deep pit on each side of the palate between the hindermost molars. Posterior to this pit the palatines usually bifurcate and unite with the pterygoids to form a lingulate or strap-shaped *palatopterygoid plate* on each side of the posterior nares. On the outside of the skull the palatines are restricted to the posterior end of the bony palate, but on the inside they reach forward along the crano facial axis all the way to the nasal chamber—a wholly unnecessary condition so far as the present structure and needs of the animal are concerned, but a highly interesting and significant relic of the primitive relations of these bones. The case is an excellent illustration of the persistence of useless parts.

The *premaxilla* is large and heavy, subquadrate in section, and articulates rather broadly with the frontal. It completely incloses the small incisive foramina except in *Zygogeomys*.

The *jugal* is a highly variable bone (as will be seen hereafter), but it is always restricted to the horizontal part of the zygoma, never creeping upward anteriorly toward the lachrymal, or inward posteriorly toward the glenoid fossa.

The *vomer* bifurcates and sends backward two long vertical wings, which articulate with the sides of the presphenoid, never with its inferior surface.

The *zygomatic arch* varies exceedingly in size and form in the different subgenera, but its horizontal part in transverse section is always distinctly triangular anteriorly, while posteriorly it is flat or rounded. Posteriorly it presents two faces, inner and outer; anteriorly a third is added—a supero-external face. The latter rarely reaches further backward than the middle of the arch and is usually set off from the outer face by a well-defined ridge, which passes obliquely backward and upward from the antero-external angle to the tip of the squamosal arm. This ridge marks the upper limit of attachment of the zygomatic part of the masseter muscle.

There is no true *postorbital process of the frontal* except in *Macrogeomys*, but the apex of the alisphenoid and adjoining anterior border of the squamosal commonly unite to form a decided *postorbital ridge*, which slopes obliquely downward and backward from the point where the frontal, alisphenoid, and squamosal meet, just behind the orbit. This ridge is made up of the edges of the alisphenoid and squamosal, and serves to sharply separate the orbit from the adjoining outer side of the brain case. In *Macrogeomys* there is a strongly developed circumscribed postorbital process, which, with the help of a corresponding eminence on the middle of the horizontal part of the zygoma, serves to sharply distinguish the orbital from the temporal fossa. In its component elements it is peculiar. Its base consists of the frontal, which bone is notched immediately in front of it, thus emphasizing the apparent size of the process. The summit of the process is made up of the apex of the alisphenoid, which here reaches the plane of the upper part of the skull and is slightly overlapped posteriorly by the antero-external angle of the squamosal.

The *paroccipital processes* stand out sideways above the condyles and are more or less expanded and flattened—never cylindrical or conical (figs. 4 and 55 *pp*, and pl. 15, figs. 6 and 7).

The *floor of the brain case*, as exposed by sawing off the vault of the cranium, affords characters of the utmost value in subdividing the group into genera (figs. 9, 56, and 68[3], and pl. 17). As will be seen on consulting fig. 9, the tympano-periotic capsules, with the inclosed basioccipital and posterior part of the basisphenoid, form about half of the floor of the brain case. The alisphenoids (fig. 9, *as*) are next in importance, the horizontal part forming a bridge across the floor of the skull above the pterygoid fossæ and immediately in front of the tympanic bullæ, while the ascending wings push forward on each side, reaching or nearly reaching the orbitosphenoids (*os*), and forming the posterior and outer boundaries of the large sphenoid fossa. Anteriorly the orbitosphenoids fill or nearly fill the front part of the floor of the brain case, on the plane of the orbital constriction. In front of this constriction, and behind the cribriform plate, the orbital or descending plates of the frontal commonly meet in the median line, forming the floor of the olfactory fossa. In young skulls, as in fig. 9, and in adults of the genera *Pappogeomys* (fig. 56), *Orthogeomys*, and *Thomomys* (fig. 68[3]), the frontals do not meet below, but the orbitosphenoids reach forward and articulate directly with the cribriform plate.

A conspicuous and highly important pair of fossæ occupy the anterior part of the floor of the brain case on each side of the median line, where they are completely surrounded by the several sphenoid bones. They may be termed the *sphenoid fossæ*. They are directly continuous and inseparably connected posteriorly with the *pterygoid fossæ* proper, which latter are widely open in front and are roofed over by the trans-

verse part of the alisphenoid only. The resulting elongated fossa as a whole may be named the *spheno-pterygoid fossa* (fig. 9, *ptf*). The shape and extent of the sphenoid fossa varies materially in the different genera, as shown in pl. 17: in *Geomys* (fig. 3) and *Heterogeomys* (fig. 1) it is much elongated, reaching anteriorly to the descending plate of the frontal. In *Cratogeomys* (fig. 9, pl. 17, and fig. 5), and also in *Pappogeomys* (fig. 56) and *Orthogeomys*, it is cut off anteriorly by the orbitosphenoids. In *Zygogeomys* (pl. 17, fig. 2) it is still further shortened by the posterior enlargement of the orbitosphenoids, which are broadly ankylosed with the alisphenoids.

The anterior end of the alisphenoid canal (fig. 9, *ac*) always opens into the outer side of the posterior part of the sphenoid fossa, and its position is essentially the same throughout the family (see pl. 17, and text figs. 9 *ac*, 52 and 54 *alc*, 56, and 68).

The *pterygoid fossæ* are large and widely open (fig. 12, *ptf*). Posteriorly they are bridged by the narrow horizontal arm of the alisphenoid (fig. 9, *as*); anteriorly they are not closed or roofed over, but are broadly continuous with the large and deep sphenoid fossæ (fig. 9, *ptf*), which open into the orbit by means of the broadly expanded lower part of the sphenoidal fissure. Their floor consists posteriorly of palatine and anteriorly of maxillary. On the inner side they are bounded by the pterygoid, the vertical plate of the palatine, the basisphenoid, and the presphenoid. On the outer side they are bounded inferiorly by the external pterygoid plate of the palatine (fig. 12, *epl*), and superiorly by the descending wing of the alisphenoid. The outer wall of the posterior part of the pterygoid fossa thus proves to be double, and the inner bone—*the external pterygoid plate*—belongs to the palatine and is overlapped by the descending wing of the alisphenoid, as shown in figs. 4 and 12.

The *sphenoidal fissure* is a large and nearly vertical pyriform vacuity at the bottom of the orbit, separating the anterior border of the alisphenoid from the descending or orbital plate of the frontal (fig. 55[3]). It separates also, to a varying degree, the alisphenoid from the orbitosphenoid (fig. 9, *sf*). Superiorly (above the horizontal plane of the orbitosphenoids) it is a narrow slit sloping obliquely upward and forward between the brain case proper and the olfactory fossa, and ending at the base of the thickened interorbital constriction of the frontal (which continues the line of separation between the olfactory fossa and cerebral chamber). This slit is permanently open except in *Zygogeomys* (in which it is closed by the orbitosphenoid), looking completely through the skull from side to side. Inferiorly (below the horizontal plane of the orbitosphenoids) the fissure is suddenly dilated, forming a broad and widely open door between the deep lateral fossa of the floor of the brain case and the bottom of the orbit. The corresponding basal parts of the fissure on the two sides of the skull are incompletely separated

by a perforate septum consisting of the vertical plate of the presphenoid, and in some cases of an ascending wing of the palatine also. The sphenoidal fissure is bounded by three bones: posteriorly by the ali-

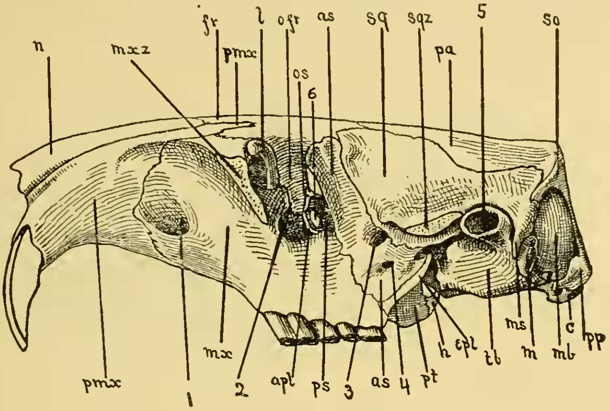


FIG. 4.—Side view of skull of *Cratogeomys merriami* from the outside. Zygomatic arch sawed off to show bottom of orbit. Animal not quite adult. Specimen from Amecameca, Valley of Mexico. (This figure should be compared with the corresponding view of *Geomys bursarius*, fig. 55.)

1 Infraorbital foramen.
2 Posterior (orbital) opening of infraorbital canal.
3 Foramen rotundum.
4 Foramen ovale.
5 Meatus auditorius externus.
6 Fenestrum in anterior part of presphenoid (the line pointing to it crosses the upper part of the sphenoidal fissure).
apl Ascending wing of vertical plate of palatine.
as Alisphenoid (the upper line rests on the ascending wing; the lower on the descending wing).
c Condyle of exoccipital.
epl External pterygoid plate of palatine bone.
fr Frontal.
h Hamular process of pterygoid bone.
l Lachrymal.
m Mastoid process of mastoid bulla.
mb Mastoid bulla.
ms Mastoid process of squamosal.
mx Maxilla.
mxz Zygomatic root of maxilla (sawed off to show orbit).
n Nasal.
ofr Orbital or descending plate of frontal.
os Orbitosphenoid.
pa Parietal.
pmx Premaxilla.
pp Paroccipital process of exoccipital.
ps Presphenoid.
pt Pterygoid.
so Supraoccipital.
sq Squamosal.
sqz Squamosal root of zygoma (sawed off).
tb Tympanic or audital bulla.

sphenoid; anteriorly by the frontal and maxilla; and inferiorly by the maxilla. The longitudinal vertical septum which forms the floor of the large inferior part of the sphenoidal fissure is likewise made up of three

bones, the orbitosphenoid, presphenoid, and palatine—though the latter is usually so reduced that it appears in the antero-inferior corner only, and in some forms can not be seen from the outside at all. But in the elongated skulls of *Geomys bursarius* and *tuza* the lower part of the fissure is broadened antero-posteriorly, and the ascending wing of

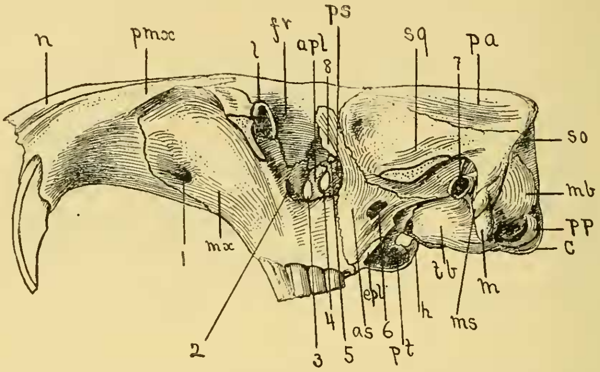


FIG. 55.—Side view of skull of *Geomys bursarius* from outside, zygomatic arch sawed off to show bottom of orbit. Animal fully adult ♂. From Knoxville, Iowa. (This figure is duplicated for easy comparison with the corresponding view of *Cratogeomys merriami*, fig. 4).

1. Infraorbital foramen.
2. Posterior (orbital) opening of infraorbital canal.
3. Vacuity in front of presphenoid and ascending wing of palatine.
4. Vacuity in presphenoid, behind ascending wing of palatine.
5. Optic foramen (in orbitosphenoid bone).
6. Foramen rotundum and foramen ovale (which have here coalesced).
7. External auditory meatus.
8. Sphenoidal fissure (upper part).

apl. Ascending wing of vertical plate of palatine.
as. Alisphenoid.
c. Condyle of exoccipital.
epl. External pterygoid plate of palatine bone.
fr. Frontal.
h. Hamular process of pterygoid bone.
l. Lachrymal.
m. Mastoid process of mastoid bulla.
mb. Mastoid bulla.
ms. Mastoid process of squamosal.
mx. Maxilla.
n. Nasal.
pa. Parietal.
pmx. Premaxilla.
pp. Paroccipital process of exoccipital.
ps. Presphenoid.
pt. Pterygoid.
so. Supraoccipital.
sq. Squamosal.
tb. Tympanic or audital bulla.

the palatine is enlarged and extended, reaching upward alongside the presphenoid (in front of the usual fenestrum) to articulate broadly with the frontal and orbitosphenoid, on or near the plane of the top of the presphenoid (fig. 55). In front of the palatine (and also in front of the presphenoid, which is here clasped between the ascending wings of the

palatine on the two sides of the skull) is a second fenestrum (fig. 55^3) anterior to the usual one (fig. 55^4, which is in the presphenoid), and likewise looking completely through the skull. This latter opening is bounded in front by the maxilla and behind by the palatine. It is situated midway between the sphenoid fenestrum and the orbital end of the infraorbital canal.

The *infraorbital canal* is small and does not pierce the root of the zygoma, but is deeply buried in the maxillary bone, passing backward and inward from the infraorbital foramen (fig. 4^1) (on the lower part of the side of the muzzle just behind the premaxillary suture) to the deepest part of the orbit (fig. 4^2), its course being wholly internal to the zygomatic root of the maxillary. It curves around the inner side of the base of the socket of the long upper incisor, and is separated from the nasal chamber by only a thin lamella of bone rising from the maxillary floor of the nasal passage and articulating above with the inferior border of that part of the os planum which supports the endoturbinals.

The *foramen rotundum* (fig. 4^3) is always situated above the *foramen ovale* (fig. 4^4), and both open into the large longitudinal alisphenoid canal. In rare instances they coalesce (fig. 55^6).

The *narial passage* is a narrow vertical ellipse, about twice as high as broad (fig. 7, *np*).

While most species of the genera under consideration develop a prominent *sagittal crest* in adult life, some do not, the temporal impressions remaining permanently distant, defining a well-marked *sagittal area*. The members of the latter category may be divided into two sets, (1) those in which the temporal impressions are actual ridges rising above the level of the surrounding bone on both sides, as in *Heterogeomys hispidus* (pl. 4), *Geomys tuza* (pl. 7, fig. 1), and *G. arenarius* (pl. 9, fig. 1); and (2) those in which the space between the temporal impressions (the *sagittal area*) is thickened and as high as the impressions, which thus appear as ridges only when looked at from the outer side, as in *Geomys breviceps* (pl. 9, fig. 6) and *Cratogeomys oreocetes* and *peregrinus* (pl. 8, figs. 2 and 3).

The *lambdoid crest* is broadly and gently convex posteriorly throughout the group (pls. 1, 2, 5–9, etc.), except in *Platygeomys*, in which genus (pl. 3 and pl. 11, fig. 4) it is strongly sinuous—forming a deep and broad reentrant angle on the median line, beyond which, on each side, it is first strongly convex backward and then slightly convex forward—the extreme mastoid ends curving backward as well as outward. The bones that take part in the formation of the lambdoid crest are the supraoccipital, squamosals, parietals, and interparietal.

There is no ossified tentorium in the *Geomyidæ*.

2. THE INDIVIDUAL BONES.

In the *Geomyidæ* there are normally thirty-three distinct bones in the skull, not counting the separate parts of the tympano-periotic capsule, the turbinated bones of the nasal chamber (which are reckoned with the bones to which they are attached) or the paired bones that coalesce before birth. The latter are the premaxillæ, maxillæ, palatines, and frontals.

The thirty-three bones that go to make up the skull (exclusive of the paired bones that are fused in the embryo) are:

Basioccipital	1	Vomer	1
Exoccipital	2	Pterygoid	2
Supraoccipital	1	Palatine	1
Interparietal	1	Maxilla	1
Basisphenoid	1	Premaxilla	1
Alisphenoid	2	Lachrymal	2
Squamosal	2	Jugal	2
Parietal	2	Nasal	2
Presphenoid	1	Periotic	2
Orbitosphenoid	2	Mandible	2
Frontal	1		
Ethmoid	1		33

The *basioccipital* is commonly truncate-wedge-shaped, with the posterior edge (*basion*) rather deeply notched. Its posterior corners enter

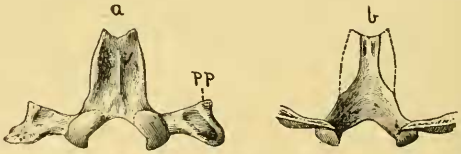


FIG. 5.—Basioccipital of *Cratogeomys merriami*, showing difference in form of upper and lower surfaces (ankylosed exoccipitals shown also): *a*, inferior surface; *b*, superior surface; *pp*, paroccipital process.

very slightly into the formation of the occipital condyles. The inferior surface of the body of the basioccipital is normally broader posteriorly than anteriorly and the decrease in breadth from behind forward is gradual (pl. 12, fig. 2, *a*); but in one species, *Cratogeomys castanops*, the body of the bone is rectangular, its sides being parallel (pl. 12, fig. 1, *a*). In another, *Orthogeomys scalops*, they may be nearly parallel or even slightly divergent anteriorly (pl. 19, fig. 2). The basioccipital varies in breadth according to the development of the audital bullæ, by which its sides are always more or less excavated. Its outer borders are usually grooved to receive a projection from the bulla. The superior surface (on floor of brain case) is always narrower than the inferior surface. The difference is very marked in some species (see fig. 5, *a* and *b*). The basioccipital early ankyloses with the exoccipitals,* but usually

* The exoccipitals coössify with the basioccipital very early in *Zygogeomys* and *Geomys* proper; somewhat later in *Cratogeomys*, *Platygeomys*, and *Heterogeomys*.

remains distinct from the basisphenoid, with which it unites by synchondrosis.

The *exoccipitals* form the whole of the condyles except the extreme lower ends, into which the outer corners of the basioccipital enter. They early ankylose with the basioccipital, forming a single bone long before the animal becomes adult. No part of the exoccipital ever projects downward below the plane of the condyles. The paroccipital processes stand out sideways and impinge upon the base of the mastoid bulla immediately behind the audital bulla; they are commonly more or less flattened and expanded, and their distal ends often project backward (fig. 12, *pp*). In *Platygeomys* they attain their maximum development and form the lateral parieties of a deep basin-shaped depression, the upper boundary of which is formed by the backward projecting lambdoid crest (pl. 15, fig. 7). The exoccipitals are in contact anteriorly with the mastoid bullæ and periotic capsules. which they partly overlap. Viewed from behind, they form the inner boundary of the exposed part of the mastoid bullæ. Vertically they reach the upper edge of the foramen magnum, and their upper border forms nearly a straight line across the plane of the occiput.

The *supraoccipital* forms a small part of the roof of the brain case and the greater part of the occipital plane, comprising all of the occipital element above the foramen magnum. On the top of the skull it reaches much farther forward in *Platygeomys* than in the other genera, (fig. 53, *so*), but is usually nearly concealed in adult life by being overlapped by the parietal and squamosal. On the occipital plane its inferior border forms the superior boundary of the foramen magnum; its outer sides curve around the basal part of the exposed mastoid bullæ, though rarely reaching laterally as far as the free ends of the mastoids. Anteriorly the supraoccipital articulates with the squamosals and parietals, and with the interparietal also in those cases in which the latter bone has an independent existence. [As a rule the interparietal is not separate from the supraoccipital.]

The *interparietal*, which has proved of considerable importance in furnishing specific characters in the *Heteromyidæ*, is small and of little consequence in most species of *Geomyidæ*, except in the single genus *Thomomys*. Even in very early life it forms an inseparable part of the supraocciptial in the *castanops* series of *Cratogeomys*, in *Platygeomys gymnurus*, in the *bursarius* series of *Geomys* proper, and in *Pappogeomys*, *Heterogeomys*, and *Zygogeomys*. It is distinct all around in early life in most species of *Thomomys*, in the *merriami* series of *Cratogeomys*, in the *tuza* series of *Geomys* proper, in *Geomys texensis* and *breviceps*, in *Platygeomys tylorhinus* and *planiceps*, but not in *P. gymnurus*. From its variability in closely related species it is evidently of little importance for purposes of classification, though its value in *Thomomys* is much greater than in any of the other genera; and it is of some value in the restricted genus *Geomys* also. In the young it is commonly subquadrate or broadly oval and of relatively large size, but with advancing age it

becomes smaller and narrowly triangular or wedge-shaped, its outer borders being resorbed from pressure of the parietals, which are constantly crowding toward the median line. Thus in *Platygeomys tylorhinus* several skulls from the same locality (Tula, Hidalgo, Mexico) present the following variations in the interparietal:

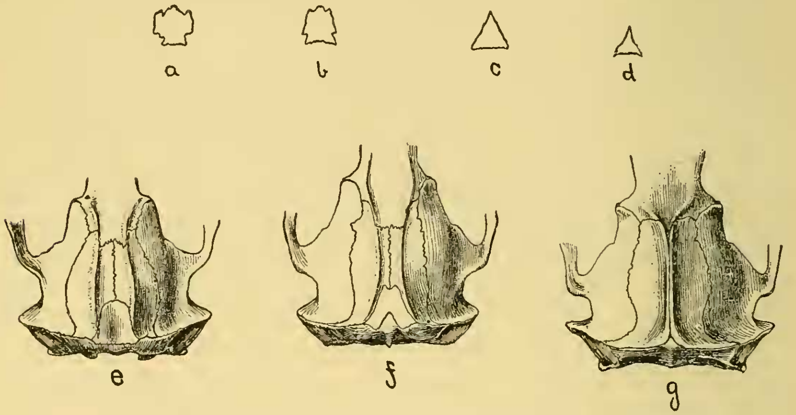


FIG. 6.—Forms of interparietal. *a, b, c, d, Platygeomys tylorhinus* showing changes with age. *e. Geomys tuza* ♂ ad. Augusta, Ga. *f* and *g G. mobilensis:* ♂ *f* yg. ad.; *g* ♂ ad. Milton, Fla. All natural size.

A very young male (fig. 6, *a*, No. 51882) has it roughly subquadrate and broader than long; an immature but older female (fig. 6*b*, No. 51884) has it of the same shape, but narrower and longer than broad; a still older specimen (fig. No. 6, *c*) has it broadly triangular; while an adult (fig. 6, *d*, No. 51883, ♂) has it reduced to a small wedge-shaped piece squeezed in between the hinder edges of the parietals.

In the young of *Zygogeomys trichopus* the interparietal is even larger than in *Platygeomys tylorhinus*, and is about twice as broad as long (measuring 8 mm. in breadth in No. 50104 juv. fig. 15, *a*). In shape it is broadly convex anteriorily and slightly (flatly) convex posteriorly. The progressive development of the powerful temporal muscles with consequent enlargement of the parietals posteriorly encroach upon its size and change its shape, pressing it into an equilateral triangle (as in No. 47186 ♂ im., fig. 15, *b*). Its size now decreases rapidly, and as the temporal impressions meet in a well-developed sagittal crest in the adult skull it nearly or quite disappears from the upper surface of the cranium (as in No. 50100 ♂ ad., fig. 15, *c*).

The interparietal is more stable in form in several of the species of the restricted genus *Geomys* than in any of the other genera under consideration. This is due chiefly to the circumstance that in this genus several species have permanently distant temporal impressions—for nothing is so destructive to an interparietal as the development of a sagittal crest. In the species possessing a crest (*bursarius*, *lutescens*, *personatus*, *fallax*, and *mobilensis*) the interparietal is normally reduced

in adult life to an inconspicuous subtriangular wedge. In the species having a permanent sagittal area it remains of considerable size and its form is reasonably constant. In *G. arenarius* it is normally subquadrate, though the anterior border may become convex from rounding off of the corners, and it is always truncate behind and persists in old age (pl. 9, fig. 1). In *G. texensis* it is normally elliptical or oval (broader than long) and convex posteriorly as well as anteriorly, projecting nearly as far behind as in front of the lambdoid suture (pl. 9, fig. 2). In *G. breviceps* it is usually reduced to a highly irregular 'wormian' bone, much cut up by contortions of the sutures (pl. 9, fig. 6). In *G. tuza* it is very large, occupying nearly half of the broad sagittal area, and is convex in front, truncate behind (fig. 6*e*). In the closely related *G. mobilensis* it is deeply notched behind and is encroached upon and finally nearly obliterated by the union of the temporal ridges (fig. 6, *f* and *g*).

The *basisphenoid* is invariably ankylosed with the alisphenoids and pterygoids, even in early life, and sooner or later usually coossifies with the presphenoid; it commonly, though not always, remains distinct from the basioccipital. Its vertical height is generally greater than its breadth, and air cells commonly develop in its substance (fig. 7, *bs*). Its chief peculiarity is the slight development of the pituitary fossa, which ordinarily is so shallow as to escape notice. But in *Heterogeomys* it is a real depression, and in *H. hispidus* it is normally a pit and completely perforates the bone. In the related species, *H. torridus*, it is much less conspicuous and never perforates (so far as the series of 26 skulls goes).

The basisphenoid articulates with the basioccipital, presphenoid, alisphenoids (by ankylosis), pterygoids (by ankylosis), and vertical plates of the palatines (by contact antero-inferiorly—see fig. 7).

The *alisphenoid* is a very important bone, serving to bind firmly together the middle segment of the vault of the cranium with the posterior part of the upper jaw, and to anchor both securely to the basicranial axis. It may be described as consisting of three parts, (1) a *horizontal* or *transverse* part, (2) an *ascending wing*, and (3) a *descending wing*.

(1) The *transverse* or horizontal part is little more than a narrow bar, inseparably connected with the middle of the outer side of the basisphenoid (figs. 9, *as* and 54, *alh*); it forms the floor of the brain case immediately in front of the periotic, and the roof of the posterior part of the pterygoid fossa, the anterior part being uncovered. In passing outward it bifurcates to inclose the large longitudinal alisphenoid canal, above which it becomes continuous with the ascending wing, and below with the descending wing. Posteriorly, the base of the horizontal part of the alisphenoid is excavated, and usually presents a cup-shaped enlargement to receive the apex of the audital bulla. It also descends alongside the basioccipital to unite with the pterygoid posteriorly.

(2) The *ascending wing* of the *alisphenoid* differs widely in form as viewed from the inside or outside of the brain case. On the outer side of the skull (fig. 4, *as*) it is a long rectangular blade ascending obliquely in front of the squamosal, with the anterior border of which it articulates. It also overlaps the posterior part of the orbital face of the frontal, rising nearly to the upper surface of the skull, which it sometimes reaches. The upper part is always roughened, and, with the overlapping edge of the squamosal, forms an oblique postorbital ridge or prominence. Sometimes the apex pushes up to the top of the skull, where it is thickened and forms the major part of a distinct *postorbital process*, resting on the frontal, and overlapped posteriorly by the antero-external corner of the squamosal. This process attains its highest development in *Macrogeomys* (see pl. 11, fig. 2, and text fig. 17[3]). Posteriorly the ascending wing is extensively overlapped by the squamosal,

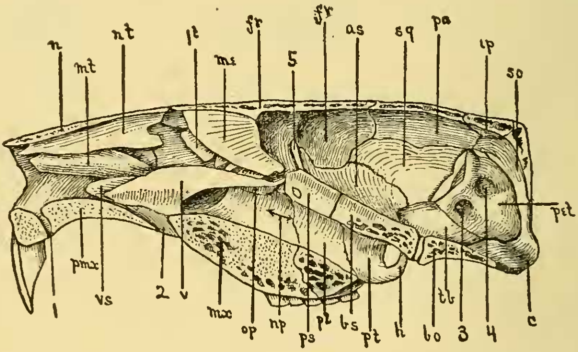


FIG. 7.—Longitudinal vertical median section of skull of *Cratogeomys merriami*, showing interior of brain case and nasal chamber. Vomer and mesethmoid in place.

1 Anterior palatine foramen.
2 Incisive foramen.
3 Meatus auditorius internus.
4 Floccular fossa.
5 Upper part of sphenoidal fissure.
as Alisphenoid.
bo Basioccipital.
bs Basisphenoid.
c Condyle of exoccipital.
fr Frontal.
h Hamular process of pterygoid.
ip Interparietal.
me Mesethmoid plate.
mt Maxillo-turbinal.
mx Maxilla.
n Nasal.
nt Naso-turbinal.
op Lower border of os planum.
pa Parietal.
pet Petrous part of periotic capsule.
pl Palatine.
pmx Premaxilla.
ps Presphenoid.
pt Pterygoid.
so Supraoccipital.
sq Squamosal.
tb Tympanic bulla (antero-superior part, which alone appears within the brain case).
v Vomer.
vs Vomerine sheath of maxilla
1*t* First endoturbinal (below and somewhat behind it the anterior ends of the second, third, and fourth endoturbinals may be seen).

as appears when examined from the inner side of the brain case (fig. 7, *as*). Therefore, while the outer face is an obliquely-vertical plate, with essentially parallel sides, the inner face is elongated horizontally, with an irregularly convex upper border—the difference being due to the fact that the outer side overlaps the frontal anteriorly and is overlapped by

the squamosal posteriorly. The alisphenoid may be separated from the orbitosphenoid as in *Heterogeomys* and *Geomys* (pl. 17, figs. 1 and 3), or the two bones may be in contact anteriorly as in *Cratogeomys* (pl. 17, fig. 5, and text fig. 9), or they may be firmly and broadly ankylosed together as in *Zygogeomys* (pl. 17, fig. 2).

(3) The *descending wing* of the *alisphenoid*, on the outer side of the skull, is a flattened plate continuous in breadth, plane, and direction with the ascending wing, and passing obliquely downward and backward between the posterior border of the maxilla and the antero-inferior edge of the squamosal (fig. 4, *as*, lower pointer). Anteriorly it forms the outer wall of the pterygoid fossa; posteriorly it overlaps the external pterygoid plate of the palatine. It articulates with the maxilla, palatine, and squamosal; and is pierced by two foramina, the *foramen rotundum* and the *foramen ovale*, which, in rare cases, merge into one. The *foramen rotundum* (fig. 4[3]) is very much larger than the *foramen ovale*, and is situated immediately below the anterior end of the squamosal root of the zygoma. It opens into the anterior part of the large alisphenoid canal, and sometimes also directly into the deep sphenoid fossa of the floor of the brain case. In *Geomys* proper it is higher up than usual and consequently opens downward into the alisphenoid canal. The *foramen ovale* (fig. 4[4]) is a small slit-like opening beneath the *foramen rotundum:* it opens obliquely upward (and usually backward) into the lower part of the alisphenoid canal. The *foramen ovale* presents considerable variation in its position and relations, affording characters of some value in separating the genera. In *Cratogeomys* it is near the anterior border of the lower part of the alisphenoid, directly beneath the *foramen rotundum* and far below the alisphenoid canal, which it reaches posteriorly by an obliquely upward and backward course. In *Platygeomys* and *Heterogeomys* it is similarly situated, except that it is nearer the middle than the anterior border of the descending wing of the alisphenoid, and is decidedly nearer the alisphenoid canal and *foramen rotundum*. In *Heterogeomys* it is not infrequently confluent on one side with the *foramen rotundum*. In *Platygeomys* it is somewhat posterior to the *foramen rotundum* and nearer it than in *Heterogeomys*. In *Zygogeomys* it is immediately below and close to the *foramen rotundum* and sometimes confluent with it; it is high up and opens *directly* into the alisphenoid canal. In *Geomys* proper it is high up also, and often becomes confluent with the *foramen rotundum* (as in fig. 55[6]). In the *tuza* series its size is unusually small.

The alisphenoid as a whole articulates with the frontal, squamosal, maxilla, palatine, basisphenoid, pterygoid, tympanic capsule, and in some genera with the orbitosphenoid also.

The *squamosal* is a large and highly important bone in the *Geomyidæ* (figs. 4, 7, 8, and 9, *sq*). It overlaps to a considerable extent the other bones of the parieties of the brain case, imparting great power of resist-

ance to the vault of the cranium. Antero-inferiorly it articulates with the alisphenoid for its entire length. Postero-inferiorly a long slit-like vacuity separates it from the audital bulla, though in some cases it is in contact with parts of the bulla. Posteriorly it overspreads the superior face of the outer part of the supraoccipital and the mastoid bulla and sends a lateral arm out sideways (the mastoid arm), which overreaches and articulates with the end of the mastoid process of the mastoid bulla. Superiorly it covers the posterior part of the frontals and broadly overlaps the parietals for their entire length—actually concealing them in one species, *Cratogeomys merriami*. The squamosal gives off the posterior root of the zygoma and articulates with the jugal. In *Zygogeomys trichopus* and *Macrogeomys costaricensis*, owing to the much-reduced size of the jugal, the squamosal arm reaches far forward and articulates directly with the maxilla—a most exceptional condition among mammals. Below the squamosal root of the zygoma is the elongated and ill-defined *glenoid fossa*, which is completed posteriorly and on the inner side by the tympanic bulla. The

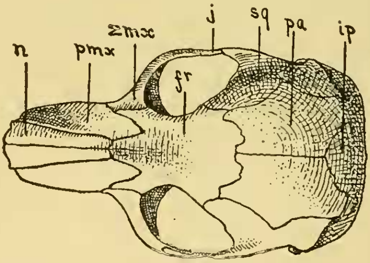


FIG. 8.—Skull of very young *Geomys bursarius* from Elk River, Minnesota. Upper surface, showing frontals ankylosed together, and interparietal inseparable from supraoccipital at birth.

fr, frontal; *ip*, interparietal; *j*, jugal; *n*, nasal; *pa*, parietal; *pmx*, ascending branch of premaxilla; *sq*, squamosal; *zmx*, maxillary root of zygoma.

form of the postglenoid notch varies from broadly U-shaped in *Platygeomys* and some others to narrowly V-shaped in *Geomys bursarius*. In *Platygeomys* and *Cratogeomys* the glenoid fossa is produced anteriorly a long distance in front of the squamosal root of the zygoma.

The mastoid arm of the squamosal enters the outer part of the occipital plane above the mastoid bulla and external to the supraoccipital, where it forms the whole thickness of the lambdoid crest (see pl. 15, figs. 3, 4, 6, and 7). In *Heterogeomys* it is vertically expanded, taking a more prominent part than usual in the occiput. The variations in the squamosal are described later (pp. 66–67).

The *parietals* complete the roof of the brain case posteriorly (fig. 8, *pa*). They do not present any unusual variations in the *Geomyidæ;* they overlap the frontal anteriorly and the supraoccipital and interparietal posteriorly, and are overlapped for their full length inferiorly by the squamosals, which in *Cratogeomys merriami* gradually overspread and conceal them. The parietals are always separate in early life, but usually coa-

lesce in the adult. The temporal impressions may remain permanently distant, defining a sagittal area, or they may unite in a prominent sagittal crest.

The *presphenoid* is a thin vertical plate of bone bridging the gap between the basisphenoid and mesethmoid cartilage and supporting, from its superior surface, the horizontally flattened orbitosphenoids (figs. 4, 7, and 9, *ps**). It is perforated anteriorly by a rather large opening, which, being opposite the sphenoidal fissure, enables one to see completely through the skull at this point (figs. 46, 10[4], and 55[4]). A second fenestrum often exists behind the first, and in *Orthogeomys* one or two small perforations usually occur in front of it. Superiorly the presphenoid supports the orbitosphenoids (fig. 9, *os*), with which it is

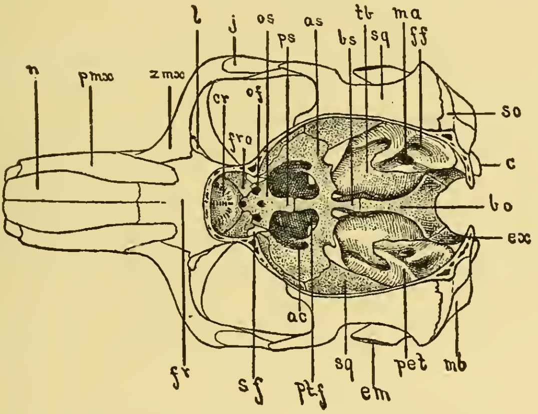


FIG. 9.—Young skull of *Cratogeomys merriami* from Amecameca, Mexico, with vault of cranium removed to show floor of brain case.

ac Anterior opening of alisphenoid canal.
as Alisphenoid bone.
bo Basioccipital.
bs Basisphenoid.
Condyle of exoccipital.
cr Cribriform plate of ethmoid.
em External auditory meatus.
ex Exoccipital.
ff Floccular fossa.
fr Frontal.
fro Descending or orbital plate of frontal (the animal is so young that the plates of the two sides have not yet united below).
Jugal.
Lachrymal.
ma Meatus auditorius internus.
mb Mastoid bulla.
n Nasal.
of Optic foramen.
os Orbitosphenoid.
pet Petrous part of periotic.
pmx Ascending arm of premaxilla.
ps Presphenoid.
ptf Spheno-pterygoid fossa.
sf Apex of sphenoidal fissure.
so Supraoccipital.
sq Squamosal.
tb Superior face of tympanic or audital bulla.
zmx Zygomatic root of maxilla.

inseparably ankylosed; anteriorly it abuts against the mesethmoid cartilage and is in contact with the ethmoid and usually the vomer; posteriorly it abuts against the basisphenoid, with which it commonly becomes ankylosed before the animal is fully adult. The ascending

*In fig. 9, which is a young skull, the presphenoid is covered by the orbitosphenoids, making it appear very much broader than it really is.

wings (vertical plates) of the palatines clasp the sides of the presphenoid inferiorly, rising anteriorly. The ends of the vomer reach it also, clasping it laterally, but never underlying it as in many mammals. The presphenoid ends anteriorly in a somewhat thickened head, with a disk-shaped cavity in front, which receives the hinder end of the mesethmoid cartilage.

The *orbitosphenoids* are a pair of thin horizontal shelves resting upon and invariably ankylosed to the upper border of the presphenoid, and articulating anteriorly with the orbital plate of the frontal (fig. 9, *os*, and pl. 17). They are normally perforated near the anterior border by the *optic foramen* (fig. 9, *of*), but in *Heterogeomys* this foramen is incomplete superiorly (pl. 17, fig. 1) except in the young. The antero-external corner sometimes protrudes through the sphenoidal fissure, bends upward, and slightly overlaps the posterior border of the descending wing of the frontal, appearing as a small scale in the bottom of the orbit. This is most often observed in young skulls. In *Zygogeomys*, *Pappogeomys*, and some forms of *Thomomys* the ascending tongue of the orbitosphenoid completely closes the upper part of the sphenoidal fissure, except a small point at its apex, which is left as a permanent foramen (pl. 18, fig. 2), and becomes ankylosed to the frontal anteriorly and the alisphenoid posteriorly (pl. 17, fig. 2). With these exceptions it does not appear in the parieties of the cranium, though it may always be seen crossing the sphenoidal fissure, which it divides into two parts. Anteriorly the orbitosphenoid invariably articulates with the upper surface of the presphenoid and the descending wings of the frontal, as already stated, and sometimes also with the palatine, maxilla, and posterior edge of the cribriform plate; posteriorly it often touches the edge of the alisphenoid, to which it becomes fixed in *Cratogeomys*, *Orthogeomys*, *Pappogeomys*, *Zygogeomys*, and some forms of *Thomomys*.

The relations of the orbitosphenoids anteriorly vary in the several groups and in some cases are exceedingly difficult to ascertain, owing to early ankylosis with the presphenoid. In *Geomys bursarius* the ascending wings of the palatine rise high on the sides of the presphenoid and articulate broadly with the orbitosphenoids, but in most forms it is uncertain whether or not the palatine is reached. The uncertainty is due to the impossibility of determining how far the orbitosphenoid descends anteriorly below the top of the presphenoid, with which it is inseparably fused. For the same reason it is uncertain whether or not the orbitosphenoids always reach the cribriform plate of the ethmoid. They seem to do so in all cases along the median line, but I have been unable, even in very young skulls, to find the place of separation anteriorly between the orbitosphenoids and presphenoid. In those genera in which the descending or orbital plates of the frontal do not meet inferiorly behind the cribriform plate, the orbitosphenoids articulate broadly with the cribriform (as in *Pappogeomys*, *Orthogeomys*, and *Thomomys*).

In *Geomys* proper the orbitosphenoids are narrower than in any of the other genera, and do not reach the alisphenoids. In *Heterogeomys* and *Platygeomys* also they usually fall short of the alisphenoid, though in extreme cases they sometimes cross the anterior edge of the alisphenoid. In *Cratogeomys* and *Orthogeomys* they articulate with the alisphenoid anteriorly for a short distance, but do not follow the upper part of the sphenoidal fissure, though in *Orthogeomys* they sometimes send a tongue upward covering part of the fissure. In *Pappogeomys* and some species of *Thomomys* they go a step further, articulating firmly and broadly with the alisphenoid and normally closing the greater part of the sphenoidal fissure above the plane of the presphenoid. *Zygogeomys* presents a still more extreme phase, the orbitosphenoid almost completely closing the upper part of the sphenoidal fissure and ankylosing broadly with the alisphenoids. From what has been said it must be clear that the orbitosphenoids play a more important part than any other bones in determining the form of the floor of the brain case, for the reason that by their expansion or contraction anteriorly they completely change the size and shape of the sphenoid fossa, which is the most conspicuous of the variable landmarks of the floor of the brain case, as may be seen on consulting pl. 17.

The *frontals* coalesce very early (probably before birth), forming a single large bone (fig. 8, *fr*) which constitutes the middle third of the upper surface of the skull and dips deeply into the orbits, where it makes important connections with the maxilla and other bones. It forms the roof of the olfactory chamber of the nasal cavity, and the roof and part of the side walls of the anterior segment of the brain case. The main body of the frontal articulates anteriorly with the ethmoid, nasals, premaxilla, maxilla, and lachrymals, and posteriorly with the parietals, squamosals, and alisphenoids. It is so extensively overlapped by the alisphenoids and squamosals that when viewed from the outside it appears much smaller than it really is.

The descending or orbital processes of the frontal (figs. 4, *ofr*, and 9, *fro*) reach far downward, burying themselves deeply among the bones of the base of the cranium and face. They articulate with the anterior border of the orbitosphenoids, clasp the sides of the presphenoid and palatines anteriorly, and articulate firmly with the maxillaries. Anteriorly, except in *Thomomys*, *Pappogeomys* (fig. 56), and *Orthogeomys*, they completely encircle the cribriform plate of the ethmoid (with which they early unite by ankylosis) and meet in the median line below it, thus reaching around the olfactory lobes of the brain case and forming the floor as well as the roof and sides of the olfactory fossa. At the point where the two arms come together in the median line, at the posterior base of the cribriform plate, a small opening is commonly left which remains as a perforating foramen passing obliquely forward and downward between the presphenoid and mesethmoid plate, and opening anteriorly into the olfactory chamber of the nasal cavity immediately

behind the lower part of the fourth endoturbinals. In *Thomomys* (fig. 61), and in the young of most of the other genera (as in *Cratogeomys*, fig. 9, *fro*), the orbital plates of the frontal are separated inferiorly by the orbitosphenoids. The variations in the form of the frontal are described further on (p. 65 and fig. 17).

The *ethmoid* is a highly complicated bone occupying the posterior part of the olfactory chamber of the nasal cavity, which it completely separates from the brain case. No part of it appears on the outside of the skull. It may be described under five heads: (1) the *cribriform plate;* (2) the *mesethmoid;* (3) the *os planum;* (4) the *ectoturbinals*, and (5) the *endoturbinals*. There is no apparent 'crista galli' in the *Geomyidæ*. [The naso- and maxillo-turbinals are completely detached, and are described under the bones to which they are respectively ankylosed, namely, the nasal and premaxilla.]

(1) The *cribriform plate* is a transverse perforated partition, separating the olfactory fossa of the brain case from the olfactory chamber of the nasal cavity (fig. 9, *cr*). It is nearly circular in outline and slopes or curves forward from the base upward. Posteriorly, in most of the genera, its entire circumference articulates (and early ankyloses) with the frontals, which usually separate it inferiorly from the orbitosphenoids, though the latter may always reach it near the median line by pushing forward beneath the frontals. To its anterior face are attached the *ectoturbinals*, *endoturbinals*, and *mesethmoid*.

(2) The *mesethmoid* bone, or perpendicular plate of the ethmoid, is a longitudinal median partition incompletely dividing the olfactory chamber into two parts (fig. 7, *me*). Its superior border is firmly and inseparably ankylosed to the frontal; its posterior to the cribriform plate. Antero-inferiorly it abuts against the cartilaginous mesethmoid, which latter reaches forward from the presphenoid and is embraced between the lateral wings of the vomer, completing the partition between the two sides of the olfactory chamber. The shape of the bony lamella varies in the different groups and seems to be quite constant in members of the same genus. In *Cratogeomys* (pl. 18, fig. 4), *Orthogeomys* (fig. 60), and *Geomys* proper (pl. 18, fig. 1), it is somewhat like a half crescent, with the base above, and the apex pointing to the end of the presphenoid, the anterior border being convex downward. In *Platygeomys* it is similar, except that the upper part is strongly rounded anteriorly, the upper edge being shorter than that part of the lamella immediately below it (pl. 18, fig. 5). In *Heterogeomys* it is relatively small and strongly convex anteriorly (pl. 18, fig. 3). In *Zygogeomys* it is nearly rectangular and the front edge is nearly straight (pl. 18, fig. 2). In *Pappageomys* (fig. 57) it is higher than long, and its inferior border dips down between the wings of the vomer—a unique condition.

(3) The *os planum* is a thin sheet of bone which lines the posterior part of the olfactory chamber (fig. 10, *op*). It supports the endoturbinals and binds them together (as may be seen by consulting fig. 10 and

pl. 19, figs. 3, 4, and 5 of *Geomys bursarius*, *Heterogeomys*, and *Zygogeomys*). Inferiorly it articulates with the vertical lamella of the maxillary which lines the nasal passage, and with the anterior ends of the ascending wings of the palatines. Near its lower border (just below the fourth turbinal), it gives off a lateral shelf, which is firmly ankylosed to the outer side of the posterior third of vomer. In *Cratogeomys* its antero-inferior border is cut off close to the turbinal folds, giving the latter a

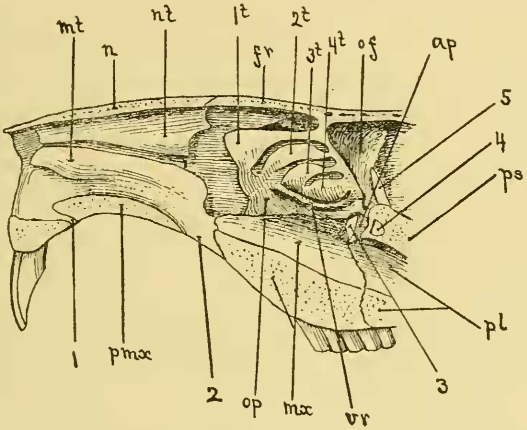


FIG 10.—Longitudal vertical median section of front part of skull of *Geomys bursarius*. Mesethmoid and vomer removed to show turbinated bones.

1 Anterior palatine foramen.
2 Incisive foramen.
3 Vacuity in front of presphenoid (present in *Geomys bursarius* and *tuza* only. It is partly overlapped posteriorly by the ascending wing of the vertical plate of the palatine, *ap*.).
4 Presphenoid fenestrum. Present in all species.
5 Upper part of sphenoidal fissure.
1t First or superior endoturbinal.
2t Second endoturbinal.
3t Third endoturbinal.
4t Fourth endoturbinal.
ap Ascending wing of vertical plate of palatine.
fr Frontal.
mt Maxilio-turbinal.
mx Maxilla (the upper pointer rests on the maxillary surface of the narial passage, the lower on the sawed body of the bone).
n Nasal.
nt Naso-turbinal.
op Os planum.
pl Palatine (the upper pointer rests on the palatine face of the narial passage, the lower on the sawed horizontal body of the bone).
pmx Premaxilla.
ps Presphenoid.
vr Vomerine ridge of os planum (unites with the lateral wing of the vomer).

particularly neat and finished appearance (pl. 19, fig. 6). In *Geomys bursarius*, on the other hand, it falls directly downward from the first turbmal, projecting as a thin sheet considerably in front of the others (fig. 10 and pl. 19, fig. 3).

(4) The *ectoturbinals* * arise from the upper and outer corners of the cribriform plate and occupy a small chamber at the maxillary root of the zygoma, incased chiefly by the frontal and maxillarybones. When the lachrymal is removed, they may be seen from the orbital side.

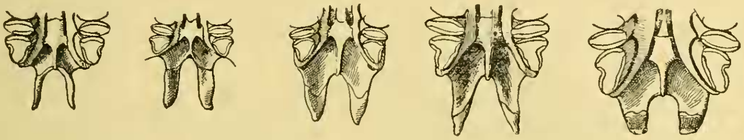
(5) The *endoturbinals* * arise from the outer sides of the anterior face of the cribriform plate (on the inner side of the ectoturbinals) and project into the nasal chamber (fig. 10). They are four in number throughout the family. Their outer sides are continuous with and form a part of the *os planum*. The first or uppermost is always the largest, longest, and most broadly expanded anteriorly. The others decrease in length from above downward, and are broadest in the middle or posteriorly. The fourth or lowermost is broader and shorter than the two middle ones. The first or uppermost is the only one that need be considered from the standpoint of variation of form in the several groups. Its front border usually slopes strongly backward (from above downward), as in *Platygeomys*, *Cratogeomys*, and *Zygogeomys;* but in *Heterogeomys* it is straight or slightly emarginate, vertical, and very broad, and carries with it the second fold (see pl. 19, fig. 5). In *Platygeomys* it is long and relatively slender, and its apex projects anteriorly behind the posterior border of the nasoturbinal (pl. 19, fig. 7). In *Zygogeomys* also it is pointed and projects far forward (pl. 19, fig. 4). In *Geomys bursarius* it is rather bluntly rounded (fig. 10, and pl. 19, fig. 3).

The *vomer* is a long and narrow plate of bone, cleft above and bifurcate posteriorly, which forms the lower part of the longitudinal vertical septum between the lateral chambers of the nasal cavity (fig. 7, *v*). It consists of a median plate and two wings. The median plate is embraced inferiorly between the wings of the vomerine sheath (which rises from the floor of the premaxilla and extreme anterior part of the maxilla). Superiorly it is split lengthwise from above, forming the two wings, between which the mesethmoid cartilage is received. These wings are narrowed posteriorly and reach the front end of the presphenoid, which they clasp laterally, but they do not appear on the inferior surface of the presphenoid, as they do in most mammals. Posteriorly the wings of the vomer separate slightly and are not united inferiorly. On the outer side they are inseparably united with the *os planum* just below the fourth endoturbinal, thus continuing anteriorly the roof of the narial passage, which is here sharply separated from the olfactory chamber above. The vomer articulates with the premaxilla, maxilla, ethmoid, presphenoid, and palatines.

The *pterygoids* are more or less quadrangular vertical plates, forming the lateral walls of the posterior nares (figs. 4 and 7, *pt*). Anteriorly they articulate with the vertical plates of the palatines; superiorly they are firmly ankylosed to the basisphenoid, and usually also with the posterior downward extension of the transverse arm of the alisphenoid.

* These terms are adopted from Dr. Harrison Allen's admirable paper on the Ethmoid.—(Bull. Mus. Comp. Zool., Cambridge, X, No. 3, 1882, 136.)

They commonly develop a hamular process (figs. 4 and 7, *h*), which curves upward and reaches or nearly reaches the audital bulla (except in *Heterogeomys*). The inferior surface of the pterygoid is usually flattened, either horizontally or obliquely; it may be of uniform breadth (fig. 11²), or much broader anteriorly than posteriorly (figs. 11³ and 11⁴). It reaches its maximum length and slenderness in *Zygogeomys* (fig. 11¹); its maximum breadth and shortness in *Macrogeomys* (fig. 11⁵). The two arms may be divergent posteriorly, convergent posteriorly, or parallel.



1 2 3 4 5

FIG. 11.—Principal types of palato-pterygoids.

1. *Zygogeomys trichopus.* 2. *Geomys lutescens.* 3. *Geomys bursarius.* 4. *Heterogeomys hispidus.* 5. *Macrogeomys heterodus.*

In the share they take in the formation of the palato-pterygoid plates on the roof of the mouth, and the manner of articulation with the palatine bones, the pterygoids present five types, as follows:

(1) They completely surround the postpalatal notch like a horseshoe, meeting or so nearly meeting anteriorly that at most a narrow spicule of the palatine reaches the notch in the median line. This type occurs in the genus *Zygogeomys* only (fig. 11¹).

(2) They form the whole or practically the whole of the sides of the postpalatal notch, but are separated anteriorly by the full breadth of the notch itself. This is the commonest type and prevails in the genera *Geomys* and *Cratogeomys* (fig. 11²).

(3) They are lingulate in shape and do not reach the base of the postpalatal notch, the palatine bones extending out a considerable distance to meet them. This is the ordinary condition in *Geomys bursarius* (fig. 11³).

(4) They are very much reduced, forming only the terminal part of the palato-pterygoid plates, the palatine part of which is greatly elongated. This condition obtains in *Heterogeomys* (fig. 11⁴).

(5) They are short, broad, and abruptly upturned, capping the ends of the very broad palatines. This type is restricted to *Macrogeomys* (fig. 11⁵).

The *palatine* bones contribute an insignificant part to the external surface of the skull (fig. 12, *pl*), but internally their connections are extensive and important (fig. 7, *pl*, and fig. 10, *pl* and *ap*). They early unite (probably before birth) in the median line, forming a single bone, which may be described as consisting of a body, two vertical plates, and two lateral wings or external ptergoid plates. The *body* or horizontal

part enters the roof of the mouth posteriorly, forming a wedge between the hinder part of the maxillaries, and never reaching further forward than the middle molars (fig 12, *pl*). This part is cut away posteriorly, so that its inferior surface is on two planes. Anteriorly it is continuous with the plane of the bony palate; posteriorly with the pterygoids. The break in the palatines between these two planes occurs suddenly between the posterior molars, forming a step or pit on each side between the last molar and a median azygos projection of the palate, which connects the two more gradually. Posteriorly the palatals may terminate opposite the anterior end of the postpalatal notch (as usual in *Cratogeomys*), or they may extend out a short distance beyond the apex of the notch (as in *Geomys* proper), or they may push back still farther, forming more than half of the side walls of the notch (as in *Heterogeomys*), or they may fail to reach the notch at all, the pterygoids coming forward to the median line (as in *Zygogeomys*). [See fig. 11 *supra*.]

The *vertical plates* are thin lamellæ, which reach upward on each side from the body of the bone to the presphenoid, surrounding the middle section of the narial passage between the maxilla and pterygoid (fig. 7, *pl*). Their upper borders reach the basisphenoid anteriorly and are in contact with the presphenoid for its entire length; anteriorly they clasp the sides of the presphenoid and articulate with the ethmoid and frontal—the descending processes of the latter overlapping their anterior prolongations. The front border of the vertical plate of the palatine, on the side of the narial passage, articulates with the corresponding part of the maxilla; the hinder border with the pterygoid. In *Geomys bursarius* the vertical plate rises anteriorly in an *ascending wing* which hugs the prespenoid anteriorly and articulates broadly with the orbitosphenoid, frontal, and maxilla (fig. 10, *ap*).

Posteriorly the body of the palatine sends off, on each side, a lateral wing—the *external pterygoid plate*—which pushes its way around behind the maxilla and along the inner side of the descending wing of the alisphenoid as far as the point where the latter is joined by the transverse arm of the same bone (immediately below the alisphenoid canal), and sometimes sends a spicule backward to the audital bulla (fig 12, *epl*). The external pterygoid plate of the palatine thus forms the outer wall of the pterygoid fossa inferiorly. It is completely overlapped externally by the descending wing of the alisphenoid, except along its inferior margin, which projects slightly below the alisphenoid, thus appearing on the outer side of the skull (fig. 4, *epl*).

The palatines articulate with the maxilla, pterygoids, alisphenoids, basisphenoid, presphenoid, frontals, vomer, and ethmoids and sometimes also within the orbitosphenoids and the tympanic bullæ.

The *maxilla* is the largest, and after the ethmoid the most complicated bone of the skull, and comprises, roughly speaking, about one-third of the entire cranium (fig. 12, *mx*). It primarily consists of two parts, which are firmly united by ankylosis in very early life (probably

before birth), forming a single strong bone for the support of the grinding teeth. It articulates with nearly all the bones of the face and with those of the anterior segment of the brain case, as follows: Anteriorly with the premaxilla, ethmoid and lachrymals; superiorly with the presphenoid and frontal; posteriorly with the palatines and alisphenoid, and externally with the jugals. The maxilla forms nearly the whole of the roof of the mouth, the palatines entering it merely as a wedge from behind. The densest and hardest part of the skull, after the floor of the premaxilla, is the median part of the maxilla between the

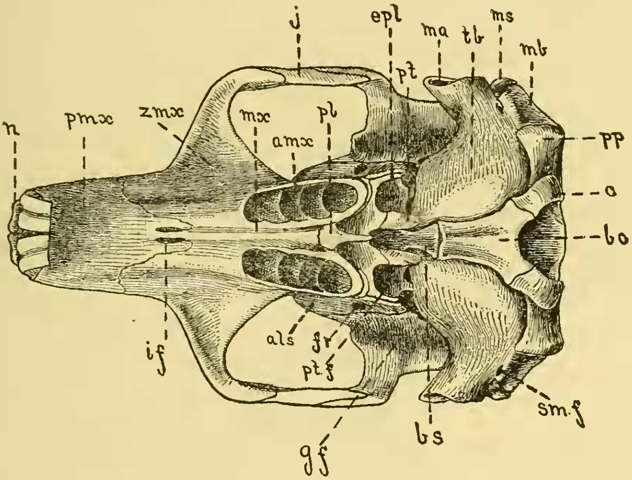


FIG. 12.—Under side of young skull of *Cratogeomys merriami*. (Specimen from Amecameca, Valley of Mexico.)

als Alisphenoid.
amx Alveolar border of maxilla.
bo Basioccipital.
bs Basisphenoid.
c Condyle of exoccipital.
epl External pterygoid plate of palatine.
fr Foramen rotundum.
gf Glenoid fossa.
if Incisive foramen.
Jugal.
ma External auditory meatus.
mb Mastoid bulla.
ms Mastoid process of squamosal.
mx Maxilla.
n Nasal.
pl Palatine.
pmx Premaxilla.
pp Paroccipital process of exoccipital.
pt Pterygoid.
ptf Pterygoid fossa.
smf Stylo-mastoid foramen.
tb Tympanic or audital bulla.
zmx Zygomatic process of maxilla.

molariform teeth. The infraorbital canal is deeply imbedded in the maxilla and is very long, reaching back from near the premaxillary suture on the side of the muzzle to the bottom of the orbit. In the *Geomyidæ* it never perforates the zygomatic root of the maxilla, but passes deeply behind it.

The maxilla gives off anteriorly a vertical lamella, which rises from the median line of the floor of the nasal chamber and projects forward a short distance into the posterior part of the vomerine sheath of the premaxilla (fig. 13, *ms*). It is split lengthwise to receive the posterior

part of the median plate of the vomer, but the resulting wings do not spread apart as in the premaxillary part of the vomerine sheath.

On each side of the nasal passage the body of the maxilla gives off a thin vertical plate or lamella, which may be termed the *internal vertical plate of the maxilla.* It forms a lining for the narial passage and articulates above with the lower edge of the os planum of the endoturbinal. The infraorbital canal passes for nearly its entire length between this thin plate and the main part of the maxilla.

The *premaxilla* is a single bone in the *Geomyidæ* (its two halves uniting before birth, fig. 12, *pmx*). It constitutes the greater part of the rostrum and forms the floor and lateral walls of the anterior half of the nasal chamber. Superiorly it embraces the nasals and articulates with the frontal and the maxillary root of the zygoma; laterally it articulates with the outer side of the maxilla a little anterior to the plane of the infraorbital foramen; inferiorly it articulates with the maxilla posterior to the middle of the rostrum, and reaches far enough backward to inclose the *incisive foramina* (fig. 12, *if*) in all except *Zygogeomys trichopus.* Anteriorly it is perforated on the median line by the

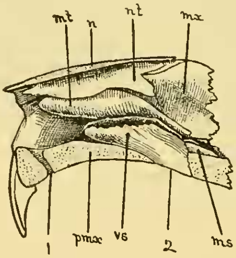


FIG. 13.—Longitudinal vertical section of nasal chamber of *Cratogeomys merriami.* The vomer has been removed to show the vomerine sheath and anterior turbinated bones.

1 Anterior palatine foramen.
2 Incisive foramen.
mt Maxillo-turbinal.
ms Maxillary part of vomerine sheath (which passes anteriorly into the premaxillary part of the sheath).
mx Maxillary.
n Nasal.
nt Naso-turbinal.
pmx Premaxilla.
vs Vomerine sheath of premaxilla.

anterior palatine foramen, which descends from the floor of the nasal chamber to the roof of the mouth, immediately behind the incisors (figs. 7, 10 and 13 [1]). On the inner side it supports the *maxillo-turbinals* and the *vomerine sheath*, which latter structure attains a high development in this group, particularly in *Platygeomys* and *Cratogeomys.*

The *vomerine sheath* (fig. 13, *vs*) is a double lamella rising from the floor of the premaxilla on the median line and projecting into the nasal cavity. It is elongated antero-posteriorly, reaching from the hinder end of the premaxilla forward over half or two-thirds the floor of the bone. Posteriorly it receives the anterior end of the corresponding (but very much smaller and narrower) part of the maxilla; superiorly it receives the median vertical plate of the vomer.

The *maxillo-turbinal*, or *inferior turbinated bone* (figs. 7, 10, and 13, *mt*), is the lower of the two turbinated bones of the anterior half of the nasal cavity (the upper being attached to the nasal). It is nearly horizontal, though usually sloping downward posteriorly, and is attached to the middle part of the inner side of the premaxilla; its free posterior end projects slightly over the front of the maxilla.

The premaxilla articulates with the nasals, frontal, maxilla, vomer, and ethmoid.

The *jugal* completes the zygomatic arch, and is always restricted to the horizontal part, never reaching down posteriorly into the glenoid fossa, and never creeping up anteriorly toward the lachrymal (figs. 9 and 12, *j*). But its variations in size and form are remarkable (fig. 14 and pl. 13). In some species it is very large and broadly expanded anteriorly (fig. 14[1]); in others it is reduced to an insignificant splint, and the zygomatic arch is complete without it (fig. 14[6]). It is commonly larger and broader in the male than the female, and sometimes

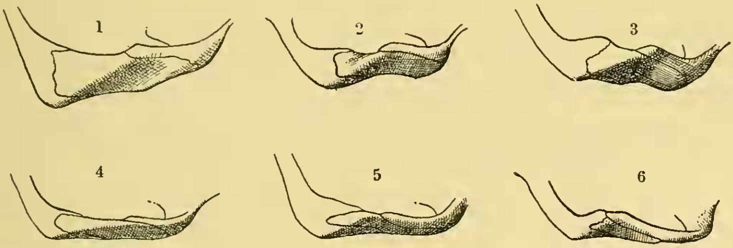


FIG. 14.—Left zygoma, showing several types of jugal.

1. *Platygeomys tylorhinus.*
2. *Heterogeomys hispidus.*
3. *Macrogeomys heterodus.*
4. *Geomys bursarius.*
5. *Cratogeomys perotensis.*
6. *Zygogeomys trichopus.*

varies greatly in species of the same genus and even in the same section. Thus, in *Platygeomys* it is greatly expanded in *gymnurus* and *tylorhinus*, and is slender throughout in *planiceps*. Similarly, in *Cratogeomys* it is broad anteriorly in *merriami*, *fulvescens*, and *castanops*, while in *perotensis* it is slender and small in every way.

The *lachrymal* is a small L-shaped bone, consisting of a *vertical* scale-like part, which closes the vacuity between the frontal and maxillary root of the zygoma at the inner corner of the orbit; and a thickened *horizontal* part which projects outward from the frontal on the upper surface of the skull and articulates also with the maxillary root of the zygoma. Its distal end is sometimes elongated and slightly recurved, and projects freely over the corner of the orbit. The principal or vertical part of the lachrymal is grooved vertically on its outer side, just anterior to the orbital face, for the lachrymal duct which passes down into the nasal chamber.

The *nasal* bones fill the interspace between the ascending arms of the premaxilla on top of the rostrum, thus completing the roof of the nasal cavity, which they slightly overhang anteriorly (figs. 8 and 9, *n*).

They are commonly ankylosed together in middle life, and not infrequently become ankylosed to the frontals also. Their actual length varies greatly in the different species. They are shortest in *Cratogeomys estor* and longest in *Zygogeomys trichopus* and *Geomys tuza*. They are commonly truncate wedge-shaped; the increase in breadth from behind forward may be gradual or abrupt. In the latter case the expansion is usually near the middle. In the *Geomys tuza* group the shape of the nasals is peculiar. They are very long and are constricted near the middle, giving them an hour-glass shape. In most of the genera (*Geomys*, *Cratogeomys*, *Platygeomys*, *Zygogeomys*) the nasals are nearly flat, though they are always more or less decurved anteriorly and rounded off laterally in front. But in some groups (notably in *Heterogeomys*) they are broadly and highly *arched* anteriorly, giving them an inflated appearance. This elevated part of the nasal supports the naked nasal pad or callosity. Inferiorly the nasals give off a descending lamella, the *nasoturbinal* bone, which is elongated antero-posteriorly and is broadest behind.

The nasals articulate with the premaxilla, frontal, and ethmoid.

The *tympano-periotic capsule* incompletely fills a broad gap in the posterior segment of the skull, between the basioccipital and squamosal (figs. 4, 7, and 9). It is held in place by several bones with which its connection is more or less intimate, but is never ankylosed to any of them except in extreme age, when the mastoid process of the mastoid bulla sometimes unites with the mastoid process of the squamosal. Its principal stays are the exoccipital and the mastoid process of the squamosal, between which the mastoid bulla is firmly grasped posteriorly. In addition to these supports, the inner border of the audital bulla commonly fits into a groove on the outer edge of the basioccipital, and the apex of the bulla rests against the base of the horizontal arm of the alisphenoid near its junction with the basisphenoid. The tympano-periotic mass as a whole thus has four normal attachments, two of which hold it firmly in place, while the others simply steady it in its position. In old age the lower edge of the squamosal sometimes reaches the upper side of the bulla and presses firmly against it.

The *tympano-periotic capsule* consists of three parts, firmly ankylosed together: (1) the *tympanic*, or audital bulla; (2) the *petrous*, or periotic proper; (3) and the *mastoid* bulla. Of these, the mastoid is posterior to the others, both of which are inseparably ankylosed to its anterior face. The tympanic protrudes from the base of the skull, forming the *audital bullæ*. The *petrous* projects into the brain case and contains the organ of hearing. No suture or other line of demarcation indicates the exact place of meeting of the mastoid with either the petrous or tympanic, but anteriorly the line of union between the two latter is always distinct. The three elements may be described as follows:

(1) The *tympanic* or audital bulla is almost wholly inferior, projecting from the under surface of the outer segment of the cranium between the

basioccipital and squamosal (figs. 4 and 12, *tb*). Anteriorly it is bounded by the *foramen lacerum medium basis cranii*, in front of which is the transverse bar of the alisphenoid. Superiorly it is separated from the squamosal by a long, irregular vacuity reaching upward and backward from the foramen lacerum medium to the tube of the external meatus, which latter articulates with the squamosal. Posteriorly it abuts against the mastoid process of the squamosal above, and the exoccipital below, and is continuous with the mastoid bulla. Externally it sends off at right angles a long tube which partly fills the postglenoid notch and opens just behind the posterior angle of the zygoma (fig. 12, *ma*). This is the external auditory meatus (fig. 4^5). The tube of the meatus curves forward and somewhat upward as well as outward, and forms the posterior boundary of the glenoid fossa, against which the condyle of the jaw strikes during the to and fro movement of mastication. The adjoining upper part of the outer side of the bulla forms the inner side of the glenoid fossa. It is thus apparent that this fossa, while mainly in the squamosal, is completed posteriorly by the tympanic bulla. The inner side of the bulla fits into a longitudinal groove on the outer edge of the body of the basioccipital, and the extreme anterior end just above the entrance of the Eustachian canal rests against the horizontal arm of the alisphenoid, which sometimes, as in *Cratogeomys*, sends back a small tongue of bone to cover its apex. The canal for the internal carotid artery is absent. On the inferior surface, between the mastoid and tympanic bullæ, is a small opening, the *stylomastoid foramen* (fig. 12, *smf*). The tympanic bulla arches over and protects the tympanum and the openings leading into the internal ear.

(2). The *petrous*, or periotic proper, in which is lodged the organ of hearing, is not visible from the outer side of the skull, but is conspicuous on the inner side (figs. 7 and 9, *pet*), where it is saddled upon the tympanic capsule, which it does not completely cover, a considerable part of the bulla protruding anteriorly (figs. 7 and 9, *tb*). The line of demarcation between the two is always evident. The anterior border of the petrous begins near the middle of the inferior margin of the inner surface of the bulla and curves upward and forward to the front end of the ridge that separates the inner from the superior surface of the bone. On the outer side of this ridge it turns back, forming a deep reentrant angle, at the apex of which is a small foramen. The petrous is commonly described as a very hard bone. It is not so in the *Geomyidæ*, but is soft and spongy, being made up of cancellous tissue like the rest of the tympano-periotic capsule. It contains the cochlea (coiled in a compact cone of 4½ turns), the semicircular canals, and the three small bones of the internal ear—the *malleus*, *incus*, and *stapes*. The petrous may be described as presenting two surfaces, a *superior* and an *inner*. The *superior* surface is narrow, slopes downward from behind forward, and is scooped out lengthwise. It is more or less completely separated from the inner surface by a ridge, which in some forms is sharply

marked; in others is inconspicuous. This ridge presents various degrees of development in the different groups. It is rounded off in *Platygeomys*, but is elevated into a distinct crest in *Cratogeomys*, *Zygogeomys*, *Heterogeomys*, and *Geomys* proper (pls. 17 and 18). It usually reaches upward and backward to the upper part of the audital mass, but in *Heterogeomys* it fails posteriorly, but forms a sharply elevated ridge from the plane of the flocculus downward (pl. 18, fig. 3). The *inner* face of the *petrous* is always perforated by the *internal auditory meatus* (fig. 7^3 and fig. 9, *ma*), above which is a depression called the *floccular fossa* (fig. 7^4 and fig. 9, *ff*). The *floccular fossa* varies in size and form in the several genera. Its position is always above and posterior to the internal meatus, from which it is separated by an elevation which sometimes amounts to a strongly developed ridge (see pls. 17 and 18). The ridge is marked in *Cratogeomys*, but not in *Platygeomys*, *Heterogeomys*, or *Geomys* proper. In *Zygogeomys* it is not only present, but a supplementary ridge bounds the floccular fossa posteriorly, leaving another depression behind it, so that the bone presents the appearance of having two floccular fossæ (pl. 17, fig. 2, and pl. 18, fig. 2).

(3) The *mastoid bulla* forms the hindermost part of the auditory apparatus (fig. 4, *mb*). It appears on the outer side of the occipital plane as a more or less rounded subtriangular mass, convex posteriorly, with the base toward the median line and the blunt apex (*mastoid process* proper, fig. 4, *m*) directed outward. It is grasped and held in place by the paroccipital process of the exoccipital below (figs. 4 and 12, *pp*), and the long mastoid process of the squamosal above (fig. 4, *ms*). The former fits into a notch on the under side between the mastoid and audital bullæ. The latter reaches far outward and curves down upon the head of the mastoid process, which it overreaches enough to effectually oppose the action of the exoccipital. The mastoid bulla, viewed from behind, differs considerably in form in the several genera, and presents specific differences also (pl. 15, figs. 3–7). It is short and rounded in *Zygogeomys* and *Geomys* (particularly in the *tuza* series). It is strongly triangular in *Macrogeomys dolichocephalus;* triangular with a constricted and elongated neck in *M. heterodus*, and much produced laterally with the inferior border concave in *Platygeomys*. Internally the mastoid bulla is made up of fine cancellous tissue.

The *mandible* is usually a large and heavy bone, strongly marked by processes and ridges for the attachment of the powerful muscles that move it. To be understood, it should be studied as a part of the cutting and slicing machine, for it consists, on each side, of a curved beam or plate built expressly to carry the ponderous chisel-edged incisors and the series of parallel cutting blades of the lower molariform teeth. The two halves are joined together by an elongated symphysis which admits of a certain amount of movement, and the adjustment is aided by a transverse muscle which helps bind the jaws together above the posterior half of the symphysis. Each half of the mandible is

strongly and rather shortly curved upward longitudinally, and is broader behind than in front; it also curves outward. There is no separation into horizontal and ascending rami, although when viewed from the inner side the condylar and coronoid part might be regarded as forming an ascending ramus. The outer side gives off posteriorly, at right angles to its axis, a strongly defined *angular process* which is always important and in some forms, particularly in *Platygeomys*, attains enormous proportions (pl. 10, fig. 8). Between the angular process and condyle is a subglobular prominence which covers the root of the long incisor. The coronoid process is broad at the base anteroposteriorly; its apex is hamular and rises above the plane of the condyle. In some forms (notably in *Platygeomys*) a strong shelf-like ridge runs from the anterior base of the coronoid to the angular process. The *masseteric fossa* is always well defined and reaches anteriorly to the plane of the front of the premolar. On the outer side of the last two molars is a large and deep pit for the insertion of the principal part of the temporal muscle (pls. 1–7). The dental foramen enters the ramus just behind this pit and just below the condylar process. Behind the symphysis, inferiorly, is a flange-like prominence for the insertion of the digastric muscle. The principal differences in the form of the mandible as a whole result from the amount of spreading posteriorly and the degree of development of the angular processes. The various types, as seen from below, are shown on Pl. 10. In some cases the base of the angular process is notched anteriorly, as in *Geomys mobilensis* (pl. 10, fig. 2.)

3. CHANGES WITH AGE.

Throughout the *Geomyidæ*, except in *Pappogeomys*, and some species of *Thomomys*, the form of the cranium as a whole, and the pattern of the sutures on the upper surface change greatly with age. The change marks the transition from immaturity to maturity—from the generalized type that stands for the group to the specialized type that bears the impress of the species. When the skull of a species fails to show marked differences with age, that species may be set down as a generalized type—one that is probably but little removed from the ancestral line. For this reason *Pappogeomys bulleri* is looked upon as very near the trunk line of the group.

The principal changes in the form of the skull as a whole resulting from age are: The broadening out of the zygomatic arches, elongation of the rostrum, expansion of the squamosal, and development of the crests and ridges that come with maturity. The anterior or maxillary root of the zygoma at first slopes strongly backward in all species, and the arches themselves are narrower anteriorly than posteriorly (as is the rule in adults of *Thomomys*). With advancing age they spread apart anteriorly until in most species they are much broader anteriorly than posteriorly. At the same time the maxillary root stands out more and more squarely until it sometimes forms almost a right angle to the axis

of the skull. The remarkable growth of the squamosal has been already described. Before birth the ascending branches of the premaxilla end about on a plane with the nasals (sometimes anterior to it), but they soon push back over the frontals, attaining their permanent relations at an early age. The muzzle increases in length from birth to maturity. This may be roughly expressed in the growth of the nasals as shown in the accompanying figure (fig. 15). In a young skull of *Zygogeomys trichopus* the nasals form 37 percent of the total length of the upper surface of the skull, while in an adult skull of the same species they form 44 percent of the total. The frontal, like the interparietal, though to a less degree, suffers from the encroachment of the parietals, and in some species from the inordinate growth of the squamosals also. In young skulls the frontal is broad posteriorly and

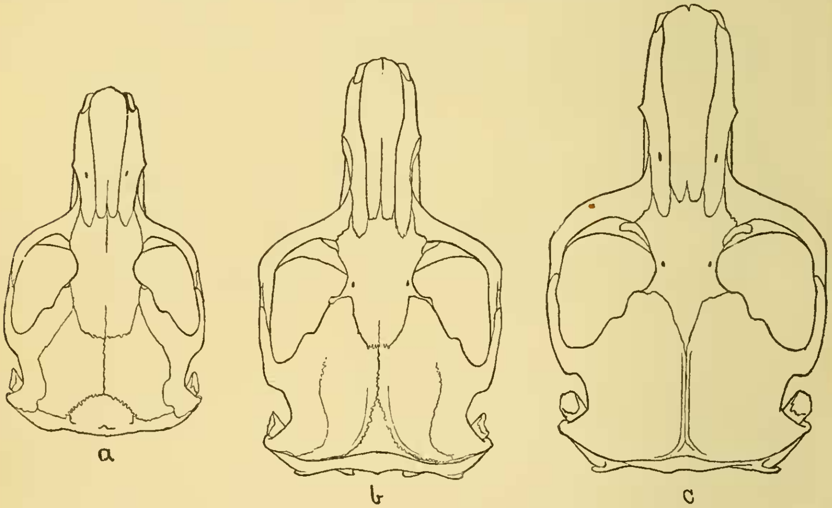


FIG. 15.—*Zygogeomys trichopus*, showing changes with age. *a*, Young; *b*, young adult; *c*, adult.

forms an important part of the roof of the brain case, as seen from above (figs. 8, 15*a*, and 16*b*). In old skulls it is reduced posteriorly, in most species, to a small wedge between the greatly expanded anterior extremities of the parietals and squamosals (see pl. 1; pl. 15, fig. 2; and text fig. 15, *c*, for adults of same species figured in figs. 8, 15, *a* and 16, *b*).

The changes in the suture pattern result mainly from the growth of the parietals both anteriorly and posteriorly, with consequent shrinkage of the interparietal, and the progressive development of the squamosal. The decrease in the size of the interparietal corresponds with the movement of the temporal impressions, which approximate with age, and in many species finally meet in a sagittal crest. The parietals not only tend to cover the interparietal by meeting posteriorly above it, but anteriorly they overlap the sides of the frontal, altering its shape entirely. The progressive development of the squamosals in some

species, as elsewhere shown, is even more remarkable than that of the parietals.

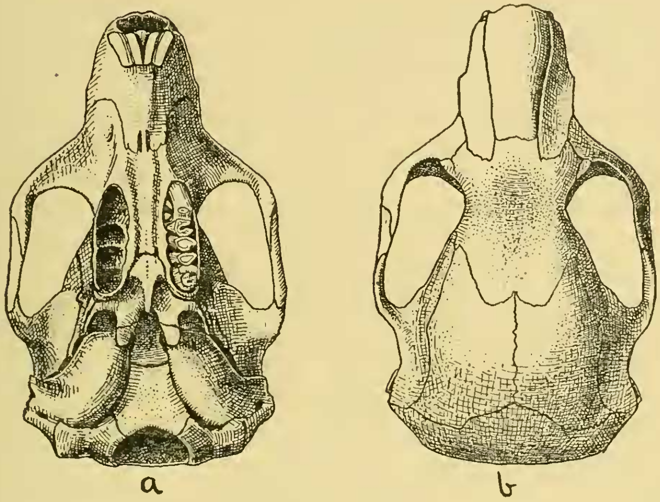


FIG. 16.—Skull of very young *Heterogeomys torridus* from Motzorongo, Mexico (No. 63643). *a*, lower surface; *b*, upper surface. For key to bones see figs. 8 and 12.

4. COÖSSIFICATION OF THE PAIRED BONES.

Nearly all the paired bones that meet in the median line become firmly ankylosed together before birth or in very early life. Those that are thus coossified are the premaxillaries, maxillaries, palatines, parietals, frontals, and frequently the nasals also. Of these, all except the parietals and nasals are ankylosed before birth (see figs. 8 and 16).

The single bones forming the basicranial axis are early ankylosed with the adjoining paired bones of the same segments. Thus the presphenoid is inseparably united with the orbitosphenoids; the basisphenoid with the alisphenoids and pterygoids; the basioccipital with the exoccipitals. The union of the lateral with the median elements of the sphenoidal segments occurs before birth; that of the occipital segment later. The exoccipitals are always distinct in early life (figs. 12 and 16), but soon become ankylosed with the basioccipital below and the supraoccipital above. The latter, except in a few species, is inseparable from the interparietal. The parietals in adult life are commonly ankylosed with the squamosals.

5. CRANIAL VARIATIONS—DEPARTURES FROM THE TRUNK LINE.

In external appearance the members of the family *Geomyidæ* are very much alike, but in cranial characters they present several marked generic types. The skulls of these types differ in size, massiveness, and degree of development of the crests, ridges, and processes from the small, thin, and smoothly rounded skulls of *Geomys texensis* and *bulleri*

to the huge angular craniums of *Platygeomys gymnurus* and *Cratogeomys merriami;* and the large, massive skulls differ in the breadth of the cranium and lateral production of the angle of the mandible from the extraordinarily broad and flat *Platygeomys gymnurus* to the long and narrow *Orthogeomys scalops* and *Macrogeomys dolichocephalus.* The skulls differ further—and this is much more important—in the relative development and relations of certain bones which here assume proportions and conditions previously unknown. Most if not all of these remarkable extremes of form are clearly secondary modifications resulting from the highly specialized types of dental armature possessed by the animals, as shown later.

The parts of the skull that exhibit the widest variation and play the most important part in giving to each type its peculiar impress or physiognomy are the *zygomatic arches*, the *roof of the brain case*, and the *occiput.* The individual bones that present the greatest range in size and form are the *frontal*, *squamosal*, *jugal*, *pterygoid*, and *mandible.*

The *zygomatic arch* varies exceedingly in size, form, and the relative development of its component elements, according to its importance as a support for the jugal part of the masseter muscle. It may be small and slender, with the horizontal part reduced to a mere rod, as in *Pappogeomys bulleri* (pl. 13, fig. 15) and *Orthogeomys latifrons* (pl. 13, fig. 16), or it may be large and massive, with the angle and horizontal arm broadly expanded, as in *Platygeomys* (pl. 13, figs. 1 and 2), *Cratogeomys* (pl. 13, fig. 4), and *Heterogeomys* (pl. 13, fig. 20). The area for the attachment of the jugal part of the masseter muscle may be small and posterior (fig. 49, *jo*), or large and extending the full length of the outer side of the zygoma (fig. 50, *jo*). The arches may be small and narrow with their outer sides nearly parallel, as in *Macrogeomys dolichocephalus* (pl. 5) and *Orthogeomys scalops* (pl. 19, fig. 1), or they may be massive, widely spreading, and broadly divergent anteriorly, as in *Platygeomys* (pl. 3) and *Cratogeomys* (pl. 2). The ratio of their breadth to the basal length of the skull varies from 54 percent in *Macrogeomys dolichocephalus* to upward of 88 percent in *Platygeomys tylorhinus*, a difference of 34 percent. They may be slightly or strongly decurved; the horizontal part may be lowest anteriorly as in *Platygeomys gymnurus* (pl. 13, fig. 2), or highest anteriorly, as in *Macrogeomys dolichocephalus* (pl. 13, fig. 19), and the angle may be small (pl. 13, figs. 15, 16, and 24) or broadly expanded (pl. 13, figs. 1, 2, 4, 17, and 18). The expansion, which normally covers the antero-external angle, as in *Platygeomys*, *Cratogeomys*, and *Heterogeomys* (pl. 13, figs. 1, 2, 4, etc.) may be drawn backward so as to occupy the middle part of the horizontal arm, as in *Macrogeomys costaricensis* and *dolichocephalus* (pl. 13, figs. 19 and 23). In the latter the zygomatic arch presents a peculiarity not observed in any other member of the group. It is narrow, broadly rounded antero-externally, without the expansion of the angle common to *Cratogeomys*, *Platygeomys*, and *Heterogeomys*, but with a moderate

expansion near the middle of the horizontal arm. This expansion is wholly on the upper or orbital side, and is restricted to the maxillary part of the arch, which here reaches much farther back than usual. On comparing the arch carefully with that of *Macrogeomys heterodus* a curious explanation is suggested, namely, that in the extreme elongation of the skull of *M. dolichocephalus* the anterior root of the zygoma has been moved forward (the posterior root being fixed), increasing the length of the maxillary arm, decreasing the breadth of the arch, obliterating the antero-external angle, elongating the laminar expansion on the orbital side, and carrying its highest point backward to or behind the middle of the orbito-temporal fossa (pl. 13, fig. 19, and text fig. 49). At the same time the upper anterior angle of the jugal has been rounded off, and the maxillary and squamosal arms of the zygoma have nearly clasped hands above it. Furthermore, the zygomatic arch as a whole has been lifted up by the main body of the masseter muscle and as a consequence the anterior end has been raised higher than the posterior (fig. 49, which should be contrasted with the corresponding view of *Platygeomys gymnurus*, in which the front of the arch is drawn down, fig. 50).

The form of the *occiput* as a whole varies considerably in the several groups. In the less specialized forms, such as *Geomys texensis*, *arenarius*, and *breviceps*, and *Pappogeomys bulleri* (pl. 15, fig. 5), it is rounded and bulges posteriorly to such a degree that the lambdoid suture is left a considerable distance in front of it. In *Zygogeomys*, *Cratogeomys*, and *Geomys bursarius* and *lutescens*, the occiput is squarely truncated. In *Heterogeomys* (pl. 15, fig. 4), *Macrogeomys* (pl. 15, fig. 3), and *Orthogeomys* it is rather high and slopes strongly forward; and in *Heterogeomys* it is particularly high above the mastoid bullæ. In *Platygeomys* it is depressed and elongated transversely and presents a unique appearance, the broad flange-like paroccipital processes curving strongly backward, defining laterally a deep basin-shaped cavity which is completed above by the overhanging lambdoid crest (pl. 15, fig. 7).

The form of the *frontal* as seen from above varies greatly in the different groups. In *Geomys*, *Cratogeomys*, *Platygeomys*, and *Zygogeomys* it is narrow and is strongly biconcave between the orbits, with the orbital margins more or less thickened and raised, leaving a longitudinal depression or groove between them (fig. 17[1]). In *Heterogeomys* it is broad, flat on top, moderately biconcave between the orbits, and shield-shaped posteriorly, owing to the elevated temporal ridges; but the orbital margins are not rounded, thickened, or raised (fig. 17[2]). In *Macrogeomys* it is moderately broad and deeply constricted between the orbits posteriorly. Immediately behind the constriction it expands abruptly at right angles to its axis, forming well-marked postorbital processes which are capped by the apex of the alisphenoid and partly overlapped posteriorly by the squamosal (fig. 17[3]). In *Orthogeomys* it is remarkably broad throughout and is not constricted between the orbits (fig. 17[4]), though the peculiar inflations at the anterior corners

of the orbits in *O. grandis* produce the appearance of a constriction behind them.

The *jugal* varies in size and shape from the large and greatly expanded plate that forms the major part of the outer side of the zygomatic arch in *Platygeomys tylorhinus* (pl. 13, fig. 1), to the rudimentary splint or scale that adheres to the inferior side of the zygoma in *Zygogeomys trichopus*, the arch being complete above without it (pl. 13, fig. 24).

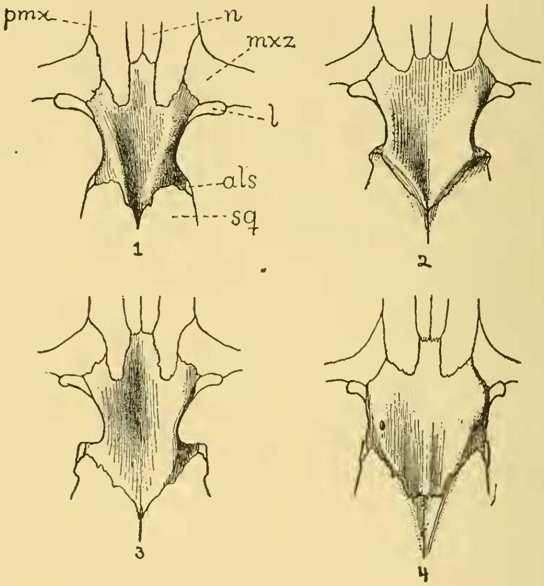


FIG. 17.—Types of frontal.

1. *Cratogeomys merriami.*
2. *Heterogeomys torridus.*
3. *Macrogeomys heterodus.*
4. *Orthogeomys scalops.*

als, apex of alisphenoid; *l*, lachrymal; *mxz*, maxillary root of zygoma; *n*, nasal; *pmx*, ascending or nasal branch of premaxilla; *sq*, squamosal.

The variation in the *squamosal* is hardly less extreme. Throughout the genus, except in the most generalized forms, this bone exhibits a singular tendency toward expansion. In *Geomys* proper the tendency is restricted to a slight overlapping of the postero-lateral moiety of the frontal and lower edge of the parietals. But in the genus *Cratogeomys* its ambition in this direction is not satisfied until the whole of the posterior half of the cranium is covered. In *Cratogeomys merriami* as the animal grows old the upper edges of the squamosals gradually creep up over the parietals until the latter are completely arched over and concealed, the squamosals actually meeting above them along the median line. In doing this the squamosals cover the posterior part of the frontal as well as the whole of the parietals and most of the interparietal, and curve up posteriorly to take part in the formation of the lambdoid crest for its entire length, thus roofing the brain with two

distinct layers of bone, the upper of which on each side, consisting of a single bone, overlaps in whole or in part five bones of the lower layer (frontal, parietal, interparietal, supraoccipital, and alisphenoid). The object of this unique arrangement is not only to furnish a brace to the zygoma, to which the powerful masseter muscles are in large part attached, but also to strengthen the vault of the cranium where the huge temporal muscles take origin. The various steps in the development of this extraordinary condition can be distinctly traced in the series of skulls of different ages of *Cratogeomys merriami* collected by Mr. Nelson in the Valley of Mexico. In *Platygeomys* another condition prevails, the squamosal expansion being chiefly *away* from the median line. On the inner side it overlaps the lower part of the parietals as usual; it then extends outward in a broad shelf, carrying the squamosal root of the zygoma far beyond its normal position, and spreading outward and backward so as to completely roof over the postglenoid space, behind which it pushes still further outward and overreaches the extreme end of the transversely elongated mastoid. In *Platygeomys gymnurus*, *tylorhinus*, and *planiceps* the lateral expansion is so excessive that the breadth of the cranium across the squamosals posteriorly is actually greater than the breadth across the widely spreading zygomatic arches (pl. 3).

The *pterygoids* vary surprisingly in size, form, and the extent to which the inferior surface enters into the lateral walls of the postpalatal notch, as already shown (pp. 52–53, and fig. 11). In *Zygogeomys* they are long and slender and encircle the notch like a horseshoe, meeting or nearly meeting in the median line behind the palate (pl. 14, fig. 1). In most species of *Geomys*, *Cratogeomys*, *Pappogeomys*, and *Orthogeomys* they are more or less parallel plates forming the greater part of the walls of the notch but not approximating anteriorly (pl. 14, figs. 7, 11, 13, 15). In *Geomys bursarius* they are more posterior, and taper to nearly a point behind, being lingulate in shape (pl. 14, fig. 2). In *Macrogeomys* they are short and broad and bend abruptly upward, capping the ends of the short and broad palatines (pl. 14, fig. 3). In *Heterogeomys* they are small, and simply form the narrow ends of the elongated posterior arms of the palatines (pl. 14, fig. 12).

The *mandible* is relatively small and light in *Geomys*. It is large and massive in *Cratogeomys*, *Platygeomys*, and the remaining groups. It is long and narrow, with short truncate angular processes, in *Macrogeomys dolichocephalus* (pl. 10, fig. 7). It is broadly spreading, with greatly elongated angular processes, in *Platygeomys gymnurus* (pl. 10, fig. 8).

The degree of development of the angular processes is correlated with definite types of molariform teeth, and affords a key to the dominant movement of the jaw in mastication, the so-called 'grinding movement' being very different in the species with and those without the greatly elongated processes. Where these processes reach their highest

development, as in *Platygeomys gymnurus* (pl. 3 and pl. 12, fig. 8, and text figs. 53 and 54) the posterior part of the masseter muscle, arising from the jugal and squamosal arm of the zygoma, is correspondingly large and effective; and since the direction of its fibers is nearly transverse to the axis of the skull, it is evident that the resulting movement of the jaw must be largely lateral. If the two parts of the masseter contract simultaneously, the resulting motion of the jaw would be oblique; if they contract independently, a to-and-fro movement would alternate with a sidewise movement.

In the species in which the lateral production of the angle of the jaw is reduced to a minimum, as in *Macrogeomys dolichocephalus* (pl. 5 and pl. 12, fig. 7; and text figs. 51 and 52) the posterior part of the masseter must be relatively unimportant, and the principal movement must be to and fro. That this is really the case is shown by the greatly restricted area of attachment for the jugal end of this part of the muscle (fig. 49 *jo*), and also by the character of the teeth. As would be expected, the crowns of the molars are broader antero-posteriorly than in the *gymnurus* group, and the tooth row on each side is bowed downward—the crowns of the upper series as a whole being convex, the lower concave, antero-posteriorly (fig. 46). Moreover, the obliquity of the plane of contact of the upper and lower series is less in *dolichocephalus* than in *gymnurus* (see figs. 52 and 54, *f*).*

* The types of molariform teeth coordinated with the two principal types of jaw movement, and hence secondarily with the development of the angular processes, are discussed at greater length under the head '*Mechanism and Dynamics of the cutting machine*' (pp. 93–97).

CHAPTER III.

THE DENTAL ARMATURE.

THE TEETH.

The dental formula of the *Geomyidæ* is the same throughout the family, as follows: $i\,\frac{1}{1}$, $c\,\frac{0}{0}$, $pm\,\frac{1}{1}$, $m\,\frac{3}{3} \times 2 = 20$

All of the teeth of the Pocket Gophers are simple rootless* tubular prisms, closed at the top and open at the base. In life the lower part is filled with a soft, pulp-like substance, supplied with blood vessels which replenish the tooth from below, enabling it to grow as long as the animal lives. The hardening of the pulp within the tooth forms

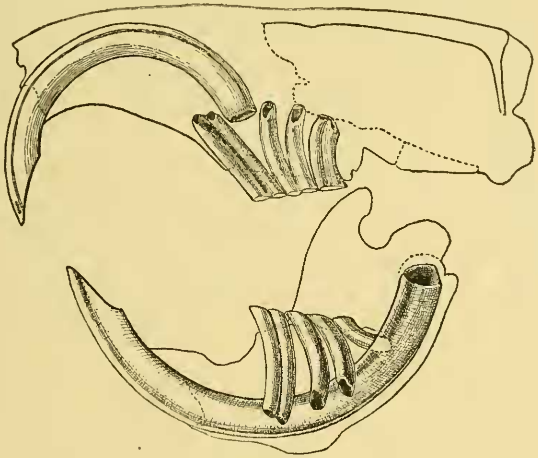


FIG. 18.—Outline of skull of *Platygeomys gymnurus*, showing teeth in situ.

the dentine and osteodentine; the enamel and cement are deposited on the outside. In the adult† the crowns of the teeth are never complicated by infoldings of the enamel; the enamel never envelops the prism continuously and never dips into the interior, but is always attached to the outside in the form of vertical bands or plates like the staves on

*Although the teeth have no true roots, it is convenient to speak of the basal or growing end as the root. The term is used in this sense in the present paper.

†The enamel caps of the young teeth, and changes in the enamel pattern due to immaturity, are fully described under a separate heading (pp. 83-86).

a barrel (pl. 16, fig. 12). The number of enamel plates on each tooth varies from one to four. When the tooth is looked at from the side, the alternating bands of enamel and cement are found to extend vertically from base to crown; and since the tooth is constantly worn down from above and as constantly replenished by growth from below, its original form is preserved and no sensible change in the enamel pattern takes place.

THE INCISORS.

The incisors are long and heavy, with trenchant, chisel-like edges (figs. 18 and 19). Their massiveness varies greatly in the different genera. The upper incisor is shortly curved in a single plane, forming a little more than a complete semicircle, and its root rests either in the upper part of the interspace between the divaricating roots of the premolar and first molar, as in *Platygeomys* (fig. 18), or directly above the root of the first molar, as in some of the other genera. The lower incisor is much longer, less shortly curved, and does not form a complete semicircle. It passes backward beneath and on the inner side of the molars, its own root rotating outward in a partial spiral like the beginning of the twist in a ram's horn, and terminates in a thin capsule of bone on the outer side of the condylar process. The lower incisor is thus considerably longer than the greatest length of the jaw, from which it projects at both ends.

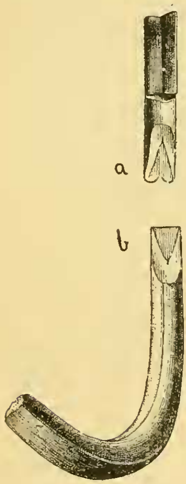


FIG. 19.—Incisors of *Platygeomys gymnurus* seen from behind. *a* upper; *b* lower.

Both upper and lower incisors have their anterior faces covered with a plate of enamel, the edges of which are bent back over the sides of the tooth far enough to hold it securely (fig. 20, *a*, *b*, and fig. 24) so that it can withstand, without danger of loosening, the great strain to which it is subjected in cutting hard roots.

On the inner side of the tooth the inflexed border of the enamel is beveled (fig. 20, *a*); on the outer side it retains its normal thickness (fig. 20, *b*). The inner edge of the tooth is squarely angular or nearly so, while the outer edge is always broadly rounded (figs. 20, 21, 22). In the lower incisor the front face of the tooth is always flat or nearly so (fig. 24); in the upper incisor it is flat in *Macrogeomys* and *Heterogeomys* (fig. 20), nearly flat or twice convex in *Cratogeomys* (fig. 21[1] and [3]), *Platygeomys* (fig. 21[2]), and *Pappogeomys* (fig. 21,[4]); and thrice convex in *Geomys* proper (fig. 22[2] and [3]) and *Zygogeomys* (fig. 22[1]).

The enamel face of the upper incisor is invariably marked (except in some species of *Thomomys*) by a conspicuous longitudinal groove or furrow, resulting from an infolding of the enamel. A second and much smaller groove is sometimes present also, always near the inner edge of the tooth. The form and position of the grooves vary in the differ-

ent species; there is also considerable range of individual variation.* Five types of sulcation prevail, as follows:

Bisulcate series:
- Principal sulcus on *outer* side of median line .... *Geomys*
- Principal sulcus on *inner* side of median line .... *Zygogeomys*

Unisulcate series:
- Sulcus median or slightly on inner side of median line; rather broadly open........................*Cratogeomys, Platygeomys, Pappogeomys, Orthogeomys*
- Sulcus at junction of inner and middle thirds; usually rather narrow and deep...*Heterogeomys, Macrogeomys*
- Sulcus close to inner side or absent.................................... *Thomomys*

In *Geomys* proper the principal sulcus is decidedly on the outer side, and the small inner groove is about one-fourth or one-fifth the distance from the inner edge to the principal sulcus; it is nearer the inner border in the *tuza* series (fig. 22³) than in the *bursarius* series (fig. 22²).

In *Pappogeomys* there is only a single groove (fig. 21⁴), and it is median or nearly so, as in *Cratogeomys*, and very deep, with the convexities on both sides strongly rounded.

In *Zygogeomys* (fig. 22¹) the principal sulcus is median or slightly on the inner side, and the fine inner sulcus is *on* the convexity of the enamel about one-third the distance from the inner side to the median sulcus. It is not so near the inner side as in *Geomys* proper. In the latter the inner convexity is flatter and the small sulcus is on its inner side instead of on the convexity itself.

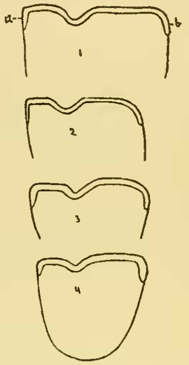


FIG. 20.—Transverse section of upper incisor in the unisulcate species in which the sulcus is strongly on the inner side. (1) *Macrogeomys dolichocephalus;* (2) *Heterogeomys hispidus;* (3) *M. costaricensis;* (4) M. *cherriei* (showing enamel face and single sulcus), *a* inner end of enamel plate; *b* outer end of enamel plate.

In *Heterogeomys and Macrogeomys* (fig. 20) the groove is always far on the inner side and sometimes wholly within the inner third. As a rule it is deeper and more abrupt than in the other genera, and the face of the tooth is flatter.

In *Cratogeomys and Platygeomys* (fig. 21) the groove, as seen by the

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*The exact position of the principal sulcus varies not only in individuals of the same species from the same place, but even on the two sides in the same skull. Thus in *Cratogeomys merriami* and *Platygeomys gymnurus* of the unisulcate series it is usually on the inner side of the median line, but several skulls of each species are at hand in which it is median on one or both sides. Similarly, in *Geomys bursarius* and *tuza* of the bisulcate series, its distance from the outer side of the tooth is sometimes noticeably different on the two teeth. Its exact position therefore can not be relied upon as a character in distinguishing species, though its approximate position is important

Many of the unisulcate teeth show, when examined closely, a faint inner groove in addition to the deep median furrow. The presence of this indistinct sulcus seems to be purely fortuitous, occurring here and there irrespective of sex, age, or species, sometimes on one side, sometimes on both, and is of no value whatever as a character. Another fortuitous variation is the occasional presence of a fine bead in the median sulcus. When present at all it is rarely symmetrical on the two teeth.

unaided eye, ordinarily appears to be median; but when the tooth is magnified it is nearly always found to lie slightly on the inner side.

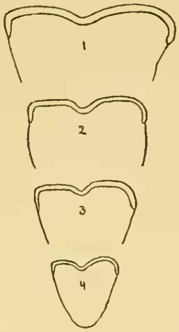

FIG. 21.—Transverse section of upper incisor in the unisulcate species in which the sulcus is median or nearly median—
(1) *Cratogeomys merriami.*
(2) *Platygeomys gymnurus.*
(3) *Cratogeomys perotensis.*
(4) *Pappogeomys bulleri.*

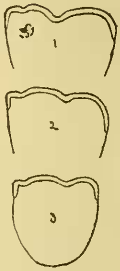

FIG. 22.—Transverse section of upper incisor in bisulcate series—
(1) *Zygogeomys trichopus.*
(2) *Geomys bursarius.*
(3) *Geomys tuza.*

It sometimes differs noticeably in position in the two incisors, and in some specimens of *C. merriami* is further away from the middle than usual.

In *Orthogeomys* the groove is on the inner side, but is usually so widely open that its outer side reaches the median line.

FIG. 23.—Transverse section of upper incisor of *Thomomys douglasi* showing shallow sulcus close to inner side of tooth.

In *Thomomys* the groove is close to the inner edge of the tooth (fig. 23) or absent. It is usually present, though sometimes very small and shallow. In a few species it is deep and strongly marked, as in *T. monticola* Allen.

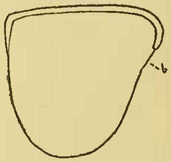

FIG. 24.—Transverse section of lower incisor of *Cratogeomys merriami*: *b*, bevel on outer side.

The outline of the incisor in cross section varies in the different species. In some forms the antero-posterior diameter exceeds the transverse; in others the transverse equals or exceeds the antero-posterior. Usually the outer side of the tooth is an even curve from the point where the inflexed border of the enamel stops, to the posterior convexity of the tooth, but this is not always the case. In the upper incisor of *Cratogeomys oreocetes*, and the lower of *C. merriami*, the outer side is emarginate, forming a distinct bevel immediately behind the reflexed enamel edge (fig. 24, *b*).

THE PREMOLARS.

The premolars are double prisms, like a figure 8 in transverse section (fig. 25 and pl. 16, figs. 8, 12, and 13). Their crowns are worn obliquely to the axis of the tooth, hence the prisms are of unequal length; the

posterior prism is longest in the upper premolar and the anterior in the lower. In size the two prisms of the upper premolar are subequal or the anterior is only slightly smaller than the posterior; in the lower, the anterior is commonly considerably narrower and more elongated anteroposteriorly. In form both prisms of the upper premolar and the posterior of the lower are transversely elliptical like the molars; but the anterior prism of the lower premolar is cylindrical or subcylindrical. Its transverse section is more nearly circular in *Zygogeomys trichopus* and the *Geomys bursarius* series than in the others. In *Macrogeomys cherriei* it is more elongated transversely than usual in the group. The neck connecting the anterior and posterior prisms is usually on or near the median line of the tooth, but in the upper premolar of *Heterogeomys hispidus* it is decidedly on the inner side.

The premolars are larger than the molars, and the lower premolar is the largest of the molariform series (fig. 26). The upper premolar is implanted very obliquely and invariably *slopes* strongly backward from root to crown, the vertical plane of the root being far anterior to that of the crown. The lower premolar is strongly curved; it is always concave anteriorly and convex posteriorly. It is implanted vertically or nearly so, though its root curves forward. The upper premolar is decidedly longer than the lower in the genus *Geomys* (both in *Geomys* proper, comprising the *bursarius-tuza* series, and in the *Pappogeomys bulleri* series); the two are subequal in all the other genera. The shaft of the upper premolar may be either straight or curved. When curved it may be convex forward or concave forward. It is straight in *Geomys lutescens*, but decidedly concave anteriorly in all the other species of *Geomys* proper and in *Pappogeomys* and *Orthogeomys*; it is strongly or moderately convex anteriorly in *Cratogeomys* and *Macrogeomys*, and faintly convex or nearly straight in *Heterogeomys*, *Zygogeomys*, and *Platygeomys*. In the latter genera it is commonly straight in the young and slightly curved in the adult.

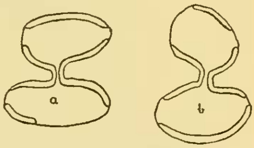

FIG. 25.—Crowns of upper and lower premolars of *Macrogeomys dolichocephalus*: *a* upper, *b* lower.

The length of prism of the upper premolar in *G. bursarius*, *tuza*, and *mobilensis* is at least one-third greater than the total length of the tooth row on the crowns (fig. 26³); in *G. texensis* it about equals the length of the tooth row. Various intermediate conditions occur in the other species. The length of the upper premolar with reference to the molars affords two series: (1) in which the premolar and m^1 and m^2 are of about the same length (comprising *G. bursarius* and most of the species in the other genera, fig. 26¹ and ²); and (2) those in which the premolar is decidedly longer than m^1 and m^2 (*G. tuza* and *mobilensis* and *Pappogeomys bulleri*, fig. 26³). The length of the upper and lower premolars with reference to each other also affords two series: In the

genus *Geomys* the lower is *much* shorter than the upper (fig. 26[3]); in the other genera (*Cratogeomys*, *Heterogeomys*, and *Zygogeomys*) the two are subequal or the lower is slightly the longer (fig. 26[1] and [2]).

THE MOLARS.

The true molars, except the last upper one (m^3), are simple single tubular prisms, elliptical in transverse section. The last upper molar is a single prism in some forms; a double prism in others. In both upper and lower series the posterior molar is the shortest tooth (fig. 26). In the lower series the teeth are successively shorter from premolar to last molar. In the upper series the premolar may or may not be longer than the first molar; the first and second molars may be subequal or either may be slightly longer than the other. As a rule throughout

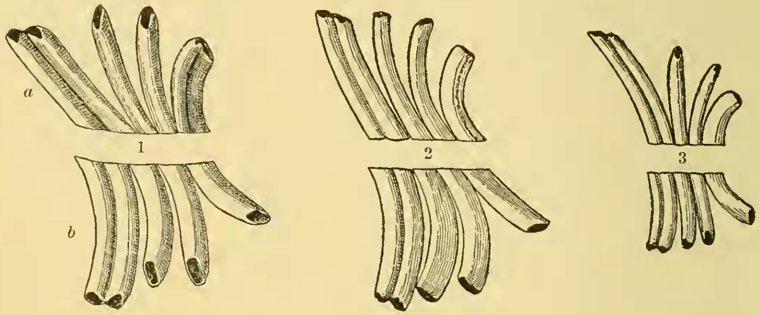

FIG. 26.—Types of molariform teeth (seen in profile): *a* upper series; *b* lower series.
1. *Heterogeomys hispidus.*
2. *Cratogeomys merriami.*
3. *Geomgs tuza.*

the group, the first and second upper molars are as long or nearly as long as the premolar. This is the case in *Geomys bursarius;* but in other species of *Geomys* proper (*tuza*, *breviceps*, and *texensis*) and in the genus *Pappogeomys* they are very much shorter. In *Pappogeomys bulleri* and the *Geomys tuza* series the longest upper molar is only about two-thirds the length of the premolar, and m^3 is only half as long as the premolar.

In the lower jaw the molariform teeth are successively shorter from before backwards, but diversity prevails in the relative lengths of the several teeth comprising the series. Thus in *Heterogeomys hispidus* m_3 is but little more than half the length of $\overline{pm}$; while in other species it is more than three-fourths. The relative length of the individual molars varies in the different species and is subject to considerable individual variation also.

The last upper molar is always the largest of the true molars. Its prism may be either single or double, or incompletely double; when double it nearly equals the premolar in size of crown, but never in length of shaft. It is invariably the shortest tooth of the upper series,

and in some species is as short as the last lower molar. It always curves backwards and the curvature is sometimes so great as to form the arc of a small circle. When a double prism, the posterior prism is always much narrower than the anterior. For purposes of classification m^3 is by far the most important tooth in the skull, its size, shape, form of crown, and enamel pattern furnishing characters of much value, as will be seen later.

The *last lower molar* is ordinarily the shortest tooth in the skull, and is always curved—the concavity posterior. In addition to the curvature, it is implanted obliquely, sloping strongly backward from crown to root, the vertical plane of the root being far behind that of the crown. Its root is also rotated backward and inward, enabling it to lie flat against the inner side of the incisor, which passes between the roots of m_2 and m_3 (fig. 41). Owing to the strong slope of the shaft of m_3, the crown is always truncated very obliquely to the axis of the tooth (fig. 18).

The prisms of the *intermediary molars* in both jaws invariably curve outward, so that their outer borders are concave and inner borders convex. The curvature is stronger in the lower than in the upper series, and strongest in m_2, whose root stands further outward (away from the median line) than any other in the series. The outer borders of the prisms are shorter than the inner borders, hence the open root-ends of the teeth always face obliquely outward. The antero-posterior curvatures of the prisms of the intermediary molars above and below take the same direction in each jaw, but vary in degree in the different genera and sometimes in species of the same genus. All of the superior molars curve backward from crown to root; the inferior intermediary molars curve forward from crown to root. In the genus *Geomys* the antero-posterior curvature of m^1 and m_2 is so slight that their prisms may be described as essentially flat (fig. 26^3). If any curvature is apparent, it is backward in m^1 and forward in m_2, in accordance with the rule. In *Zygogeomys* and *Heterogeomys* the curvatures are slight; in *Orthogeomys* they are marked, and in *Macrogeomys*, *Cratogeomys*, and *Platygeomys* they are very strong, m^1 and m^2 curving strongly backward and m_1 and m_2 strongly forward (fig. 26^1 and ^{2}).

In addition to the curves described, the molar prisms are always more or less twisted on their axes. If the teeth were long enough these twists would result in spiral curves.

The axes of the elliptical crowns of the intermediary molars are in a general way transverse to the axis of the skull; but they rarely stand out at right angles. As a rule they slope obliquely forward or obliquely backward. When the crowns of the upper molars slope backward from the median line the crowns of the lower molars are transverse or slope forward, and *vice versa*. The axis of the crowns of m^1 and m^2 normally slopes backward in *Geomys*, *Pappogeomys*, and *Cratogeomys;* it is normally transverse or slopes forward in *Platygeomys, Orthogeomys, Macrogeomys*, *Heterogeomys*, and *Zygogeomys*.

VARIATION IN FORM OF LAST UPPER MOLAR.

The form of the last upper molar affords excellent characters. In its simplest type, as in the genus *Geomys* (comprising both the *tuza* series and the *texensis-bursarius* series) it is a single prism and the shape of the crown varies from suborbicular to subtriangular (figs. 27 [1] and 33). In *Pappogeomys* (fig. 27 [2]) the form of the tooth is similar except that there is a decided emargination on the outer side, anterior to the middle, behind which the prism is abruptly narrower. This is the first step in the formation of the 'heel' or posterior lobe, which is so conspicuous in *Orthogeomys*, *Heterogeomys*, and *Macrogeomys* (fig. 27 [6] and [7]).

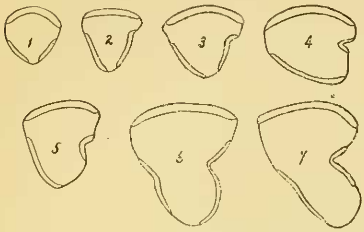

FIG. 27.—Types of form of crown of last upper molar (m 3).

1. *Geomys breviceps.*
2. *Pappogeomys bulleri.*
3. *Platygeomys gymnurus.*
4. *Cratogeomys estor.*
5. *Zygogeomys trichopus.*
6. *Macrogeomys dolichocephalus.*
7. *Macrogeomys heterodus.*

In the genus *Cratogeomys* the tooth is partly converted into a double prism by a vertical groove on the outer side (fig. 27 [4]). This genus presents the widest latitude of individual variation known in the family, indicating that the tooth is in a transition state and has not yet attained a condition of stable equilibrium.

It is much more variable in *Cratogeomys* than in *Platygeomys*. Taking both genera together the crown presents all sorts of intermediate patterns, from a form in which the posterior prism is hardly more differentiated than in *Pappogeomys bulleri*, to forms having this prism produced to such a degree that the superficial resemblance to *Heterogeomys* is marked (fig. 35). But it lacks the stability of form and fixity of enamel pattern characteristic of the members of the latter genus.

The variation is greater in the adult than the young, as would be expected from the increased obliquity of the crown with reference to the axis of the tooth in advanced age, and naturally is most marked in the length and form of the heel. Sometimes in old age the crown is worn so obliquely that the heel actually overhangs, acquiring an exaggerated length very different from its transverse section (as in fig. 28, *d*).

FIG. 28.—Variations in crown pattern of m 3 in *Cratogeomys fulvescens*.

In *Cratogeomys fulvescens* (fig. 28) the variations in form and enamel pattern of crown are pronounced, but most of them are easily reducible to one or the other of two types: (1) An obcordate crown, deeply notched between the prisms on the outer side, with the axis of the posterior loop or heel nearly transverse and the outer enamel plate reduced

to a small U-shaped piece protecting the sulcus (fig. 28, *a*); and (2) a more or less subtriangular or even trefoil-shaped crown with the axis of the posterior loop very oblique (sloping strongly backward as well as outward), and the outer enamel plate more or less elongated (fig. 28, *c*, *d*). In form the second is easily derived from the first by a slight backward rotation of the transverse axis of the posterior loop. Regarding the shape of the crown as more or less subtriangular, the apex of the triangle is always toward the median line of the skull and the notch or emargination always on the outer (buccal) side. *Cratogeomys castanops* (fig. 29) stands somewhat apart from the other species. The double character of the prism is not well marked; the posterior part of the crown is rather broadly rounded, the lateral enamel plates are rather short, and the inner one is situated far back. Both tend to disappear in extreme age—doubtless from atrophy of the enamel organ.

FIG. 29.—Variations in crown pattern of m^3 in *Cratogeomys castanops*.

In the genus *Platygeomys* the crown is subtriangular, narrow behind the anterior prism, and the axis of the heel is normally antero-posterior, as in *Pappogeomys* (fig. 27^3).

In *Macrogeomys*, *Heterogeomys*, and *Orthogeomys* (fig. 34), the tooth is a double prism, the anterior and posterior moieties of which are separated by a groove or depression on each side—that on the outer side being invariably the deeper, that on the inner side being in rare cases obsolete. The posterior prism is always narrower than the anterior (the narrowing is chiefly on the outer side), and its antero-posterior diameter is usually greater. The crown as a whole is thus longer than broad, and is composed of two parts or lobes: an anterior which is broader than long (being transversely elliptical, like the other molars); and a narrow posterior lobe or 'heel' which is commonly longer than broad, and varies in form and proportions in the different species.

In *Heterogeomys* the grooves on the two sides are nearly opposite, and the anterior prism is narrowly elliptical. In *Orthogeomys* and *Macrogeomys* the sulcus on the inner side is commonly decidedly posterior to the plane of the outer sulcus. In *Macrogeomys* the anterior prism is broadly elliptical, and the posterior is elongated antero-posteriorly. In *Macrogeomys heterodus* the posterior lobe or heel is very long and slopes obliquely outward; the inner face of the tooth as a whole is unusually flat (fig. 27^7).

In *Zygogeomys* the last upper molar is an imperfect double prism, the depression on the inner side being slight, while that on the outer side is much deeper. The crown as a whole is longer than broad, and the posterior loop or heel ends in a broad lip-like extension not protected by enamel and hence subject to change of shape by wear (see fig. 27^5),

ARRANGEMENT OF THE ENAMEL.

After the enamel cap of the newly born young has been ground down far enough to expose the upper ends of the cement bands, the arrangement of the enamel remains the same throughout the life of the individual and affords excellent generic and in some cases specific characters. The enamel never envelops the prism in a continuous sheet, but is deposited in the form of vertical plates or bands which always alternate with bands of cement. These bands are disposed in a definite manner on each tooth of the series. In the under jaw the number in each tooth is the same throughout the group; in the upper jaw the number varies in the several genera.

Premolars.—The permanent *upper* premolar has three enamel plates (one anterior and one lateral on each side*) in the genera *Geomys* proper, *Pappogeomys*, *Cratogeomys*, and *Platygeomys*—the posterior being altogether absent (fig. 30[1]). In *Zygogeomys*, *Heterogeomys*, *Macrogeomys*, and *Orthogeomys* the number is increased to four by the addition of a posterior plate, which, however, never covers more than half of the posterior face of the posterior prism, and is always restricted to the inner or lingual side (fig. 30[2] c). In *Orthogeomys* the posterior plate is sometimes obsolete. The permanent lower premolar always has four enamel plates, the posterior being invariably present and covering the whole hinder face of the tooth (fig. 25, *b*, and fig. 32).

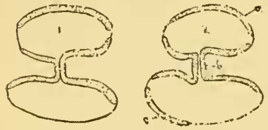

FIG. 30.—Types of enamel pattern of upper premolar.
(1) *Cratogeomys merriami*;
(2) *Heterogeomys hispidus*; (*a*) anterior enamel band; (*b*) lateral band; (*c*) posterior band.

First and second upper molars.—In the first and second upper molars, which are simple elliptical prisms, the normal number of enamel plates is two, one covering the anterior, the other the posterior face of the tooth, with a narrow interval filled with cement at each end between them (fig. 31[1]). In many species, however, the posterior plate is obsolete (fig. 31[2]). It is present and covers the whole hinder side of the tooth in *Geomys*, *Pappogeomys*, *Macrogeomys*, *Heterogeomys*, and *Orthogeomys*. It is present but restricted to the inner or lingual half of the tooth in *Zygogeomys* (fig. 31[3]), and is altogether absent in *Cratogeomys* (fig. 31[2]) and *Platygeomys*.

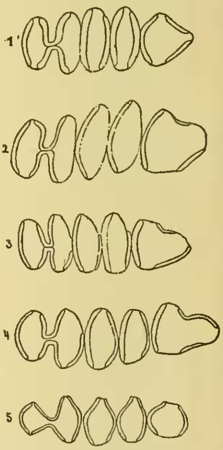

FIG. 31.—Types of enamel pattern of upper molariform series in the different groups:

1. *Geomys bursarius*.
2. *Cratogeomys castanops*.
3. *Zygogeomys trichopus*.
4. *Macrogeomys cherriei*.
5. *Thomomys bulbivorus*.

* In both upper and lower premolars the anterior enamel plate is convex forward; the lateral are strongly bent, conforming to the sulcus between the prisms and extending from the convexity of one to that of the other. The resulting shape in transverse section is usually like that of the letter U, with the opening directed outward and the base resting on the median line of the tooth.

Last upper molar.—Throughout the *Geomydiæ*, except in *Thomomys*, the last upper molar has three enamel plates—one anterior, one on the inner side, and one on the outer side, with interspaces (cement bands) of varying breadth between (fig. 27). In *Orthogeomys scalops* the outer plate is normally divided (fig. 62). The anterior plate always covers the whole front face of the tooth, and is the same in all species; the two others vary in length and shape, and furnish excellent characters. In *Thomomys* there are but two plates, an anterior and a posterior (fig. 31[5]).

Lower molars.—Except in *Thomomys*, the lower molars have each but a single enamel plate; it completely covers the posterior face of the tooth, the anterior face and sides being covered with cement (fig. 32, *a*). In *Thomomys* each lower molar has two enamel plates, an anterior and a posterior (fig. 32, *b*).

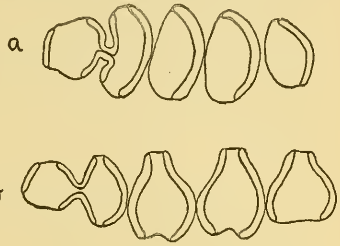

FIG. 32.—Crowns of lower molariform series: (*a*) *Geomys bursarius;* (*b*) *Thomomys bulbivorus.* Except in *Thomomys* (*b*) the enamel pattern is the same throughout the family (as in *a*).

PRINCIPAL DIVISIONS INDICATED BY THE ENAMEL PLATES.

The foregoing study of the enamel plates shows that all of the 37 species and subspecies herein described, and all the species of *Thomomys*, may be arranged in five principal groups, according to the presence, absence, or relations of the posterior enamel plate in the upper molariform series, as follows:

1. Posterior enamel plate absent in pm and present in m¹ and m² .... *Geomys, Pappogeomys, Orthogeomys.**
2. Absent in both *pm* and m¹ and m² .... *Cratogeomys, Platygeomys.*
3. Present on inner (lingual) side in both *pm* and m¹ and m² .... *Zygogeomys.*
4. Present on inner (lingual) side in *pm* and complete in m¹ and m² .... *Heterogeomys, Macrogeomys, Orthogeomys.**
5. Present in *pm* and m¹, m², and m³ .... *Thomomys.*

NORMAL NUMBER OF ENAMEL PLATES—SUMMARY.

The number of enamel plates actually present in the different teeth has been shown to vary from one to four. The number on each tooth has been found constant in the lower series; inconstant in the upper series. The lower premolar (which is a complete double prism) invariably has four, and the lower molars one each, except in *Thomomys* in which they have two (fig. 32). The upper premolar (a complete double prism) has four in some genera; three in others. The upper intermediary or elliptical molars (m¹ and m²) have two in some genera; one in

** Orthogeomys* is losing the posterior enamel plate of the upper premolar. It is present in *O. latifrons*, but greatly reduced or altogether absent in *nelsoni* and *scalops.*

others. The last upper molar (an incomplete double prism) invariably has two in *Thomomys* and three in all the other genera. These facts indicate that the normal number of enamel plates in simple elliptical prisms is two, and that one has been suppressed in all of the elliptical molars having only one (the lower molars in all except *Thomomys* and the first and second upper in *Platygeomys* and *Cratogeomys*), and in the upper premolar when it has only three plates (as in *Platygeomys*, *Cratogeomys*, *Pappogeomys*, and *Geomys* proper). This view is supported by a study of the mechanics of the grinding process. (See pp. 90–97, 107–108).

VARIATIONS IN ENAMEL PLATES OF LAST UPPER MOLAR (m^3).

Throughout the family, except in *Thomomys*, the last upper molar is strengthened by three vertical plates or bands of enamel, alternating with three interspaces filled with cement (figs. 33, 34). The anterior of the three enamel plates is constant in form and relations; the two others inconstant. The anterior invariably covers the whole front face of the tooth and is convex forward (the convexity may be slight or great). The others vary in position, shape, and relative breadth. In a single species, *Orthogeomys scalops*, the outer plate is normally divided (fig. 62). In the simplest forms, in which the tooth is a subcylindric or subtriangular prism, as in *texensis*, *breviceps*, and allied species (fig. 33), they are simple vertical bands of enamel, subequal in size, one on

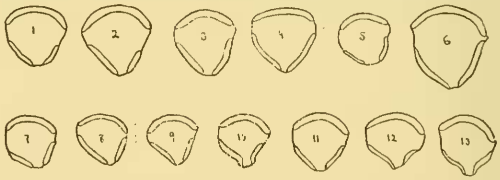

FIG. 33.—Variations in form of crown and enamel pattern of m^3 in restricted genus *Geomys*.

1, 2. *Geomys tuza*.
3. *tuza floridanus*.
4. *mobilensis*.
5. *arenarius*.
6. *Geomys personatus*.
7—10. *texensis*.
11—13. *breviceps*.

either side of the tooth posteriorly, separated from one another and from the anterior enamel plate by similar vertical plates or bands of cement. The genus *Geomys* proper presents no variations from this type except in the relative breadth of the inner (lingual) and outer (buccal) enamel bands. The inner is more constant than the outer and is commonly somewhat broader.* Sometimes the two tend to define a lip posteriorly (fig. 33[10] and [13]). Marked departures from this simple type occur in those species in which the last upper molar is a double instead of a single prism; and since various intermediate conditions in

*In *G. tuza* the outer plate is much narrower or shorter than the inner. Since the teeth are commonly looked at endwise from above, the enamel pattern is ordinarily seen in transverse section, and the three enamel plates appear as narrow bands on the periphery of the prism. Their *breadth* on the sides of the tooth is shown in the *length* of the band as it appears on the crown. In describing the pattern, therefore, it is convenient to use the term *length* instead of *breadth* to designate the relative width of the vertical enamel plates.

the evolution of the double prism are presented by living species, so the several stages in the adaptation of the lateral enamel plates to the development of a posterior loop or heel are clearly shown. These changes consist in a lengthening or shortening of the enamel plate (as it appears on the crown of the tooth) and in the development of a bend or flexure by virtue of which the enamel conforms to the curvature of the anterior and posterior loops, resulting from the development of a deep sulcus on one or both sides of the tooth in those species that have a double prism. And since the sulcus on the outer side appears first and is always deepest, it follows that the outer enamel plate is the one most affected and shows the greatest range of variation (fig. 34).

Outer (buccal) enamel plate.—The first step in the formation of a distinct and permanent flexure may be seen in *Pappogeomys bulleri* (fig. 34, [1]), in which species the anterior end of the outer enamel plate bends

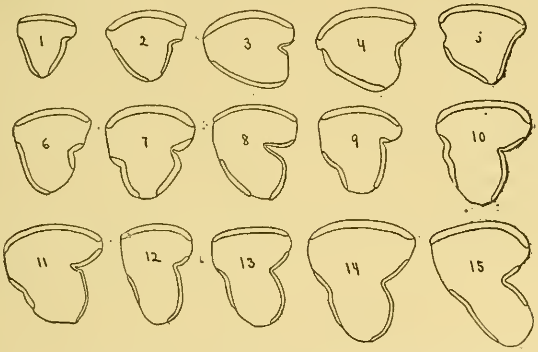

FIG. 34.—Forms of crown and enamel pattern of m³ in the genera in which this tooth is a double prism.

1. *Pappogeomys bulleri.*
2. *Platygeomys gymnurus.*
3. *Cratogeomys estor.*
4. *oreocetes.*
5. *peregrinus.*
6. *Zygogeomys trichopus.*
7. *Orthogeomys latifrons.*
8, 9. *Orthogeomys nelsoni.*
8. *Totontepec;* 9. *Comaltepec.*
10. *Heterogeomys hispidus.*
11. *torridus.*
12. *Macrogeomys cherriei.*
13. *costaricensis.*
14. *dolichocephalus.*
15. *Macrogeomys heterodus.*

outward in front of the vertical sulcus that marks the outer side of the tooth. A slightly more accentuated condition is found in *Platygeomys gymnurus* (fig. 34, [2]). The extreme development of this flexure is attained in the genera *Heterogeomys* (fig. 34, [10] and [11]), *Macrogeomys* (fig. 34, [13], [14], [15]), and *Orthogeomys* (fig. 34, [7] and [8]), in all of which the bend is essentially a right angle—a result of the deepening of the sulcus between the prisms. At the same time the posterior arm of the enamel plate is considerably lengthened in order to protect the elongated posterior lobe or heel to which it conforms. In *Orthogeomys* and all the known species of *Heterogeomys* and *Macrogeomys* the posterior limb is about double the length of the anterior; and except in *M. heterodus* it actually reaches the hinder border of the tooth. In *Orthogeomys scalops* a very remarkable condition prevails; the outer enamel plate is normally divided (fig. 62).

In *Platygeomys* the outer enamel band is normally either straight or bent outward at the extreme anterior end—not U shaped as in *Cratogeomys* proper.

In the remaining groups a widely different condition obtains: The outer enamel plate is much reduced, and as a rule the two arms are subequal. This type prevails in *Cratogeomys* proper and in *Zygogeomys*—groups whose interrelations are distant and obscure. In *Cratogeomys* the outer plate is normally (?) reduced to a mere angle or U-shaped piece at the bottom of the sulcus that gives the outer side of the tooth the semblance to a double prism (fig. 35, [5] and [6]), leaving a wide unprotected interval (cement band) on each side. It is variable, however, and in some specimens the posterior arm reaches nearly to the end of the heel (fig. 35, [8]). The difference may be sexual; but owing to the difficulty in determining the sex in these animals, which difficulty is greatly increased in the case of the young, it is unsafe to place much reliance on the sex marks accompanying the specimens. Still there is reason for suspecting that those specimens in which the outer plate is elongated posteriorly are females. The variation is much greater in some species than in others. It is most extreme in *C. castanops* (fig 29), and least, so far as our material goes, in *C. perotensis* and *estor*. In advanced age it sometimes happens that the lateral enamel bands become abnormally short on one or both sides and very rarely become divided in the middle. Accidents of this sort are probably the result of shrinkage or atrophy of the enamel organ.

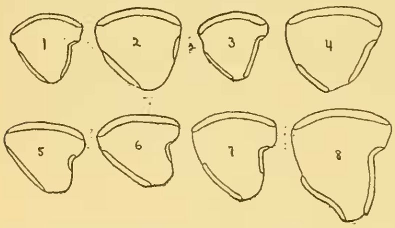

FIG. 35.—Variations in form of crown and enamel pattern of m^3 in *Platygeomys* and in *Cratogeomys merriami*.

1, 2. *Platygeomys gymnurus*.
3. *Platygeomys tylorhinus*.
4. *Platygeomys fumosus*.
5–8. *Cratogeomys merriami* (all from Amecameca, Mexico).

In the genus *Zygogeomys* the outer angle is more open and the enamel plate covers about half of the outer side of the tooth.

The outer enamel plate is slightly longer than the inner in *Platygeomys*, and much longer in *Heterogeomys*, *Orthogeomys*, and *Macrogeomys* (except in *M. heterodus*); it is subequal or shorter in all the other known forms.

Inner (lingual) enamel plate.—The inner plate is much less variable than the outer, as previously stated. It is straight or slightly convex, except in the few species that have a real sulcus on the inner side, converting the tooth into a complete double prism. In these its anterior part curves or bends outward. This condition is known in the three genera, *Heterogeomys*, *Macrogeomys*, and *Orthogeomys*. In *Heterogeomys* the outward curvature is slight (fig. 34, [10] and [11]); in *Macrogeomys dolichocephalus* and *Orthogeomys latifrons* it is strong (fig. 34, [14] and [7]). In

length and position the inner plate is much more variable: It reaches the hinder end of the tooth in *Geomys* proper, *Cratogeomys*, *Pappogeomys*, *Platygeomys*,* *Zygogeomys*, and *Orthogeomys;* falls slightly short of the end in *Macrogeomys*, and very considerably short in *Heterogeomys*. In *Heterogeomys* it barely covers half of the inner side of the tooth; in all the other known species it covers nearly two-thirds or more than two-thirds of the inner side. The condition in *Heterogeomys* therefore is clearly exceptional.

CHARACTERS OF THE UNWORN TEETH.

Specimens of pocket gophers young enough to show the deciduous premolars and the unworn crowns of some of the molars are so exceedingly rare that I have seen but four in the entire series of specimens of this genus examined in the preparation of the present paper. Two of these are *Geomys bursarius* from Elk River, Minn., collected by Vernon Bailey April 29, 1888, and May 14, 1886 (Nos. 4909 and 2927, Merriam collection); the third is a young *Geomys mobilensis* from Milton, Florida. The fourth is a juvenile specimen of *Heterogeomys torridus* from Motzorongo, Mexico, collected by E. W. Nelson March 5, 1894 (No. 63643, U. S. N. M.). The unworn teeth are so much alike in the two genera that they may be described together.

Incisors.—In both genera the grooves in the front face of the upper incisors are very much deeper and larger than in the adult, and the convexities are much more strongly rounded. In the young of *Geomys bursarius* the two grooves do not present the disproportion characteristic of the adults, the small inner groove being relatively much deeper and larger, though by no means so large as the median groove.

Deciduous premolars.—The crown of the upper deciduous premolar is much elongated and has an anterior prism in addition to the double prism of the permanent tooth (pl. 16, figs. 1 and 3). The double prisms are united on the inner (lingual) side, forming a U-shaped grinding surface (with the opening directed outward) in front of which, separated by sulcus, is the small transversely elongated summit of the anterior prism. The crown of the lower deciduous premolar is likewise much elongated, and it is irregularly and incompletely divided into three lobes (pl. 16, figs. 2 and 4*b*). Both upper and lower premolars have the anterior and posterior roots far apart, and the permanent premolar may be seen between them (fig. 36, and pl. 16, figs. 1–4, *a*).

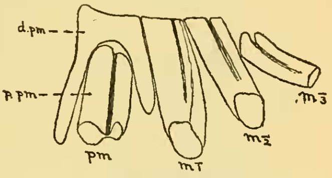

FIG. 36.—Lower molariform teeth of a very young *Geomys bursarius*, showing deciduous and permanent premolar in situ, and unworn crown of m_3 which has not yet reached the plane of the crowns of the other teeth.

*In *Platygeomys fumosus* the inner enamel band seems to be normally shorter than the outer, and only half or less than half the length of the anterior band (fig. 35[4]).

Permanent premolars.—One of the upper deciduous premolars (pl. 16, fig. 1*b*) has been removed from the baby skull of *Heterogeomys torridus*, exposing the unworn crown of the permanent premolar (pl. 16, fig. 1*x*). The permanent premolar also has been removed and figured in several positions to show the form, size, and relations of its primitive enamel cap (pl. 16, figs. 5, 6, and 7). For ready comparison, the corresponding tooth in an adult of the same species has been figured also (pl. 16, fig. 12). On reference to pl. 16 it will be seen not only that the crown of the young premolar is completely enveloped with enamel, but that the enamel cap reaches down over the shaft of the double prism, covering nearly half of the tooth (figs. 5, 6, and 7) and passing continuously into the four enamel bands that alone remain in the adult (fig. 12*). The fact that the young of the various species as usually obtained rarely show any trace of the enamel cap indicates that the growth of the young teeth and grinding down of the crowns progress with surprising rapidity. A very young *Cratogeomys castanops* from Las Animas, Colo., collected by Dr. A. K. Fisher, has only a remnant of the enamel cap left (pl. 16, fig. 14).

The unworn crown of the *upper* premolar (pl. 16, figs. 1 *x*, 5, 6, 7) has a single transverse crest on the anterior prism, an incompletely double transverse crest on the posterior prism, and an oblique ridge connecting the two on the inner side. The single crest of the anterior prism is notched or bifid at the apex, and has a small upright lobule at the base of the notch on the inner side. The double crest of the posterior prism is open on the outer side, and the crest as a whole is roughly and narrowly U-shaped. The summit of the anterior crest is bilobate; that of each arm of the posterior crest is irregularly trilobate or trituberculate.

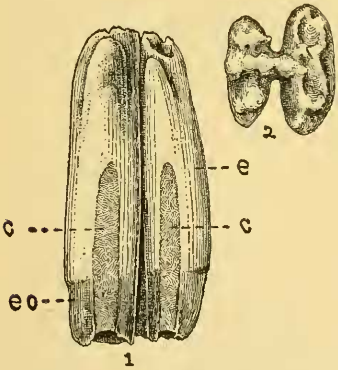

FIG. 37.—Right lower unworn permanent premolar of *Heterogeomys torridus*: (1) inner or lingual side; (2) enamel cap from above; *c*, cement bands; *e*, enamel; *eo*, enamel organ.

The enamel cap of the permanent *lower* premolar is a complete double prism, each moiety of which bears an independent transversely elongated crest (fig. 37). The summit of the anterior crest (fig. 37[2]), is trituberculate; that of the posterior is incompletely double, being split lengthwise into two unequal parts, the posterior of which is the shorter and more irregular. The trituberculate crest of the anterior prism is bilaterally symmetrical. There are two large tubercles or lobes, one on each side, and a smaller median one, which is much elongated antero-posteriorly and is continuous with the ridge connecting the anterior and posterior prisms.

*In figs. 5, 6, 7, and 12 the cement bands are shaded, thus serving to bring out the enamel more distinctly.

Molars.—In all of the young skulls under consideration the deciduous premolar and the intermediary molars (m 1 and 2) have been used, and their enamel caps have been partly ground down, while the permanent premolars and last molars have not yet suffered attrition. The *premolar* has been already described. The enamel cap of the *last lower molar*, which has not yet reached the plane of the crowns of the other teeth (fig. 38 and pl. 16, figs. 2, *d*, 4, *d*, and 9, *d*), presents two complete transverse crests, each of which has an undulating summit incompletely divided into three lobes. The two crests are separated by a deep furrow and show no tendency to come together at any point. The enamel cap covers a little more than half of the tooth (fig. 38, *e*). The *last upper molar* (pl. 16, figs. 1, *c* and 3, *c*) has just reached the level of the other teeth. Its unworn crown in both genera presents a well-defined anterior and a less distinctly defined posterior crest, separated by an interspace which is bridged over by an oblique enamel ridge on the inner side of the median line. The anterior crest is incompletely trilobate. The posterior crest is thickened and less symmetrical than the anterior, and in *Heterogeomys torridus* (pl. 16, fig. 1, *c*) it is incompletely double, being partly divided by a transverse excavation.

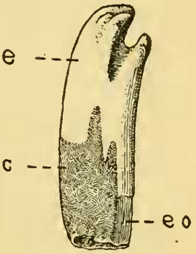

FIG. 38.—Right last lower molar of very young *Heterogeomys torridus* (from same specimen as fig. 37); inner or lingual side, showing unworn enamel cap, and relations of enamel and dentine lower down: *c*, cement bands; *e*, enamel; *eo*, enamel organ.

The crowns of the first and second upper molars present different degrees of wear in the three young specimens at hand, and none of them are young enough to show the transverse crests by which they were undoubtedly crowned before the tops of their enamel caps were ground down. The wearing, however, has not progressed so far as to obliterate the double crowns characteristic of immaturity except in the upper molars of one specimen of *G. bursarius* (No. 4909). In the other skull of this species (No. 2927) a transversely elongated loop of enamel incompletely divides the grinding surface of m^2, indicating the former presence of two transverse loops, as in the lower molars. In the lower series the double crowns are well shown in both *Geomys bursarius* (pl. 16, fig. 4) and *Heterogeomys torridus* (pl. 16, fig. 2). In one skull of *Geomys bursarius* (pl. 16, fig. 4) the second lower molar is only slightly worn, and its crown presents two transverse loops separated by a decided depression. In the other skull it is more worn, but still is incompletely divided. The crown of the first lower molar in both skulls is deeply notched on the inner side and slightly on the outer, showing that when unworn it resembled the others.

Summary.—The summits of the unworn molariform teeth in *Geomys* and allied genera are not only completely covered with enamel, but the enamel cap is complicated by crests and tubercles. The permanent premolar, which is a double prism, has a single transverse crest over

the anterior prism and a partly double crest over the posterior. The true molars are bilophodont, each carrying two transverse crests. In the case of the last upper molar, the posterior crest is thickened and somewhat irregular and may represent the coalescence of two crests. It is joined to the anterior by an oblique ridge on the inner side. In the premolar and last molar, above and below, the summit of each crest is more or less distinctly divided into two or three lobes or tubercles. There is every reason to believe that the crowns of the intermediary molars (m^1 and ^{2}) are similarly crested-tuberculate when in the unworn condition, but in the specimens at hand their summits are worn down too far to show it.

The crowns of the unworn teeth are bilophodont in all the lower molars and in the first and second upper molars. The premolar and last upper molar (m^3) may be considered as imperfectly trilophodont, the posterior prism in each instance being incompletely double.

The theory that permanently rootless teeth with flat grinding crowns are more primitive and less specialized than rooted teeth with tuberculate crowns receives a decided setback in the circumstance that the young unworn molars in the *Geomyidæ* are provided with crested-tuberculate enamel caps, and that the adult teeth, though simple when considered singly as individual prisms, constitute, when taken collectively, one of the most highly specialized grinding and cutting machines thus fardiscovered.

CHANGES IN FORM AND ENAMEL PATTERN OF YOUNG TEETH RESULTING FROM WEAR.

As already stated, the bilophodont crowns of the embryo and very young molars are hardly ever seen, the wearing down of the primitive enamel cap proceeding so rapidly that the youngest specimens ordinarily coming under the eye of the naturalist have flat grinding surfaces as in the mature animal. During the reduction of the young crown four different types of enamel pattern, representing as many stages of wear, succeed one another as follows:

First stage (before the crests are completely obliterated): *two parallel disconnected transverse loops.*

Second stage (when the sulcus between the crests is reached): *a figure 8.*

Third stage (after the sulcus is passed and before the tops of the cement bands are reached): *a continuous ring or circle.*

Fourth stage (after the tops of the cement bands are reached): *the pattern of the mature tooth*, consisting of from one to three bands of enamel alternating with the same number of bands of cement, as already explained in detail.

The first stage is of brief duration; the second still more evanescent; the third decidedly longer than the first and second together; the fourth continues throughout the life of the animal.

During the early part of the fourth stage the form of the shaft of the tooth changes, the double prism characteristic of extreme youth giving place to the single elliptical prism of the adult (except in the last upper molar, which in some genera remains permanently double). It seems remarkable that a tooth having a large double crown like the first and second lower molars of the very young animal (pl. 16, figs. 2 and 4) should be capable of changing its form to that of the single transverse ellipse of the adult (pl. 16, fig. 17) in a very brief period and without molting the tooth. That it does so is not open to question, and may be demonstrated by making a section of the lower part of the young tooth. This has been done in the case of the second lower molar, as shown in pl. 16, fig. 4, where 4*x* is a transverse section of the same tooth from the lower fourth. The antero-posterior diameter of the tooth decreases from above downward and the vertical groove on each side becomes shallower and shallower and finally disappears. The change in the shape of the crown takes place naturally by the rapid wearing down of the grinding surface, which brings successively lower parts to the top.

THE ENAMEL ORGAN.

Throughout the group the enamel organ is situated at the base of the teeth, as usual in rodents having prismatic molars. In the young tooth the enamel organ is very much larger than in the adult, owing doubtless to the greater rapidity of growth in early life. Thus on referring to pl. 16 (figs. 5, 6, and 7) it will be seen that the enamel organ occupies about one-fifth of the length of the upper premolar in a very young animal, while in the corresponding tooth of an adult of the same species (fig. 12) it occupies only about one-fifteenth of the length of the tooth. In extreme age partial atrophy of the enamel organ sometimes takes place, causing a shortening of the enamel on that side. In a few instances an enamel plate has been found divided in the middle, due doubtless to atrophy or injury of the enamel organ in the same vertical plane.

OSTEODENTINE.

A core of osteodentine traverses the central part of each tooth. In the premolars and all of the molars except m^3 it forms a large elliptical shaft in the middle of each prism. In m^3, whether single or double, the osteodentine is a single core, conforming in shape to the shape of the tooth. On all sides it passes into the true dentine, by which it is completely enveloped except at the free ends. At the lower end it passes insensibly into the growing pulp. In other words, the osteodentine is a central core consisting of the hardening pulp and containing the vessels by means of which the tooth is nourished. In the *Geomyidæ* it forms a considerable part of the substance of the tooth, as usual in prismatic teeth growing from persistent pulps. In the genera *Geomys* and *Cratogeomys* it is pale buffy or yellowish brown in color, and conse-

quently not conspicuous. In the genera *Heterogeomys* and *Zygogeomys* it is dark brown, in striking contrast to the white of the rest of the tooth.

MECHANISM AND DYNAMICS OF THE CUTTING MACHINE AS A WHOLE.

The individual teeth have been described. It remains to consider them as parts of a complex and highly specialized mechanism for cutting and slicing the food, to describe the muscles that operate the machine, to mention other structures concerned in the act of mastication, and to show how a bit of root or other hard vegetable tissue is cut loose, sliced, and reduced to pulp ready to pass into the stomach.

The primary object of the dental armature is twofold: (1) To enable the animal to bite or chisel off pieces of the hard vegetable substances on which it feeds, and (2) to reduce these pieces to a condition of minute subdivision suitable to be turned over to the stomach for digestion. The incisors serve the additional purpose of bars, axes, and picks in helping the animal overcome the various obstacles encountered in driving its tunnels through different soils. When the front teeth are used for this purpose, the resulting dirt and chips are kept out of the mouth proper by a furry partition, elsewhere described, which divides the mouth as a whole into two chambers.

MANNER OF ATTACHMENT OF THE TEETH.

The way the teeth are fastened in their sockets is in harmony with the other remarkable adaptations of the grinding apparatus. The attachment is effected by means of the periosteum of the alveolus, which does not invest the teeth, but is firmly adherent to the cement bands, leaving the enamel faces free. Thus each tooth is suspended by one or more vertical cushions, which extend all the way from root to gum. This method of attachment not only relieves the tender pulp at the base of the tooth from pressure, but gives to the cutting edge or edges an elasticity that must be highly effective. In the case of the incisors, the area of attachment is very extensive, comprising the whole of the tooth below the gum except the enamel face. The lower molars throughout the entire group, and the intermediary upper molars in the genus *Cratogeomys*, are attached in the same way on one side only—the side opposite to the enamel or cutting edge. In the case of the upper premolars the principal attachment is along the posterior face of the posterior prism, while a supplementary band on each side of the anterior prism serves to keep the cutting edges always in place. In those species in which the posterior prism of the upper premolar develops an enamel band on its inner or lingual side, the tooth is suspended by four cement bands. The lower premolar is attached by four narrow lateral bands. The last upper molar is invariably held firmly in place by three cement bands, one on each side anteriorly and one on or near the median line behind.

DYNAMICS OF THE INCISORS.

The upper incisor has been shown to curve in the arc of a circle, to cover a little more than a complete semicircle, and to lie in a single plane (figs. 18 and 19). Its root is very long with relation to the length of the muzzle, always overreaching the first upper molar. It is implanted in such manner that its cutting edge is directed downward and slightly backward. The lower incisor has been shown to curve outward in an incomplete spiral, and to traverse the entire length of the mandible—its root projecting on the outer side of the condylar process, where it is incased in a thin capsule of bone. This small capsule contains the pulp from which the tooth continually grows to replace the wear at the other end. The extreme development of these teeth is proportionate, of course, to the strain put upon them in chiseling hard roots. The upper incisor is subjected to less strain than the lower, and its principal function seems to be to anchor the cutting machine to the substance operated on, while the greatly elongated lower incisor does most of the work. The free end of the lower incisor slopes forward and upward, its angle of implantation being different from that of the upper. Thus, while the upper incisor remains stationary, its recurved and usually divided tip enabling it to hold fast to the object to be cut, the lower incisor plays rapidly back and forth like a steam drill, its straight enamel edge doing the cutting.

The great length of the incisors within the alveolus is necessary in order to counterbalance the length of the part that protrudes beyond the jaws, and also to afford a large surface for attachment within the alveolus so as to relieve the growing root from pressure. The way the teeth are attached to the jaw by a long belt or cushion, which envelops all but the enamel face, gives to the cutting edge an elasticity that must be of great service, not only in increasing the efficiency of the act of chiseling, but also in relieving the tooth from jar.

It remains to notice the interesting secondary modifications of the skull and molariform teeth, by means of which the animal is enabled to open the front part of the mouth wide enough to use the incisors to advantage. The molariform teeth stand much higher out of the jaw anteriorly than posteriorly, and their roots increase in length proportionally (fig. 18). The premolars, both above and below, protrude twice or more than twice as far as the last molars. Thus, when the mouth is shut and the teeth pressed firmly together, the jaws are at least twice as far apart at the anterior as at the posterior end of the molar series. Now, the distance from the crown of the premolar to the cutting edge of the upper incisor is two and one-half to three times the length of the molariform series on the crowns, and the axis of the skull is nearly parallel to the plane of the crowns of the molar teeth. Hence, without any other help and with the mouth shut, the ends of the jaws (where the incisors cut the gums) would be from five to six times fur-

ther apart than at the plane of the posterior molars.* This arrangement permits the necessary protrusion of the incisors, the cutting edges of which, as a rule, reach the plane of the crowns of the molars in the upper jaw and slightly pass this plane in the lower jaw. The great advantage of this arrangement is most apparent during the act of biting off hard roots, when a very slight opening of the mouth proper, entailing only a slight separation of the molars, is sufficient (multiplied along the length of the strongly divaricating jaws) to separate the chisel ends of the incisors widely, enabling them to grasp objects of comparatively large size.

DYNAMICS OF THE MOLARIFORM TEETH.

(a) *Manner of implantation and curvatures.*

The angle of implantation of the molar series as a whole in both upper and lower jaws is peculiar. A transverse section of the skull (fig. 39) shows that the roots of the upper molars are nearer the median line than the crowns.† It follows that the upper tooth rows are strongly *divergent* from root to crown (fig. 39, *e*). In the lower series the converse occurs, the tooth rows *converging* from root to crown (fig. 39, *f*). The upper molars slope strongly and curve moderately outward from root to crown, while the lower molars both slope and curve strongly outward from crown to root.

The crowns of the opposing series do not meet in a horizontal plane, but are obliquely truncated: the upper series face obliquely *downward and outward;* the lower series obliquely *upward and inward* (fig. 39). When the jaws are shut, lateral movement in a horizontal plane is impossible. If a circle is drawn around the upper molars (fig. 40) it is at once apparent that during the lateral movement of the mandible the crowns of the teeth move sideways in the arc of a circle, thus giving the utmost possible mechanical advantage. The axis of rotation is in or near the basicranial axis, and the axis or arc of oscillation is short, as in a pendulum. To enable the teeth to withstand the great pressure to which they are thus subjected, they have developed very long roots

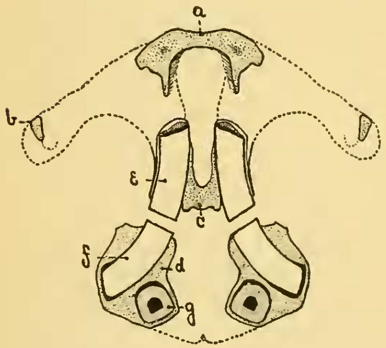

FIG. 39.—Transverse section of skull of *Platygeomys gymnurus*, showing manner of implantation and relations of molariform teeth. *a*, Frontal; *b*, zygoma; *c*, palate; *d*, mandible; *e*, upper molar; *f*, lower molar; *g*, incisor.

* The actual condition is not exactly as here described. In the case of the lower jaw the distance is *decreased* by the upward curvature of the anterior end of the jaw and the shortening of the diastema. In the upper jaw it is *increased* by the excavation of the under side of the rostrum between the molars and incisors.

† The roots of the upper premolars are even nearer together than those of the molars; they are, in fact, almost in contact.

and a system of complex curvatures and oblique implantations, and are suspended in their sockets by vertical bands of periosteum, as already described. When the jaws are shut, the molars on each side curve outward so strongly that the distance between them below (between roots of lower series) is several times greater than above (between roots of upper series). The result of this arrangement is that the molar teeth, during the lateral movement of the act of grinding the food, press upon the opposing series not only in such manner as to secure the greatest mechanical advantage, but also so as to produce the least jar, since the pressure in both directions is distributed over arcs of circles. But this is not all, for if the tooth rows are viewed from the side another remarkable complex of curvatures appears (figs. 18 and 26).

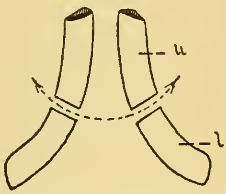

FIG. 40.—Upper and lower molars of *Platygeomys gymnurus* in normal position, showing angle of truncation of crowns, necessitating lateral movement in arc of circle.

It is now seen that in addition to the lateral curvatures there are strongly developed antero-posterior curves and incomplete spiral curves. In the upper series the premolar always slopes strongly forward, and the molars curve backward from crown to root. In the lower jaw the premolar and intermediary molars (m_1 and m_2) curve forward from crown to root and the posterior molar backward. The lower premolar is the largest and heaviest tooth of the molariform series; it is strongly concave forward, convex backward, and is implanted nearly vertically. The last molar is the smallest tooth, and both slopes and curves strongly backward from crown to root. The end teeth of each series thus act as braces to support the tooth row as a whole during the antero-posterior movement of the jaws in grinding, and to keep the molars constantly 'keyed up,' so preventing any tendency to spacing between the crowns.

In addition to the curvatures described, the molariform teeth are usually more or less twisted spirally on their vertical axes, so that the two ends lie in different tangential planes. Furthermore, the outer (concave) edge is commonly shorter than the inner (convex) edge.

FIG. 41.—Cross section of mandible of *Platygeomys gymnurus*, showing how roots of m_2 and m_3 straddle the incisor.

The molariform teeth are so implanted that the roots of each lateral series, above and below, lie in at least two antero-posterior planes, the roots of the premolar and last molar in both jaws being nearer the median line of the skull than those of the intermediary molars. The discrepancy is most marked in the lower series, where the posterior lower molars (m_2 and m_3) actually straddle the root of the incisor (fig. 41). The roots of m_1 and m_2 curve down outside (on the buccal side) of the incisor, while that of m_3 lies on its inner (lingual) side. In order to do this the latter tooth (m_3) not only curves strongly

backward but is twisted on its own axis sufficiently to enable its root to lie flatwise against the inner side of the incisor.

(*b*) *Influence of the direction of the jaw movement on the molariform teeth.*

The direction of the dominant movement of the jaw exerts a marked effect upon the size, curvatures, proportions, and number of enamel plates of the molariform teeth. This is well shown in comparing teeth from skulls of the same size of *Macrogeomys dolichocephalus* and *Platygeomys gymnurus*.

(1) *Effect on the size and curvature of the prisms.*—The length of the molariform series on the crowns is approximately the same in both. In *M. dolichocephalus*, in which the principal movement is antero-posterior or nearly so, the premolars and last molars, which form the end posts of the series, are very much lengthened and enlarged, while the intermediary molars are essentially the same size as in *P. gymnurus*, in which animal the principal movement is transverse or obliquely transverse. The lower premolar of *dolichocephalus* (fig. 42, *a*) contrasted with that of *gymnurus* (fig. 42, *b*) is not only larger and longer, but its root curves forward much more strongly, increasing its resisting power as a brace. Throughout the group this tooth (the lower premolar) acts as an immovable post or buttress against which the molars press during the to and fro grinding movement; hence it is naturally largest in those species in which the principal movement is antero-posterior (see fig. 26).* The intermediary upper molars (m^1 and m^2) are longer and less curved in *dolichocephalus* than in *gymnurus;* the intermediary lower molars (m_1 and m_2) are essentially equal in length in the two forms and are equally curved, but the curvatures are different: In *M. dolichocephalus* the upper half of the prism is nearly straight, particularly in m_2; the curvatures are more abrupt; the anterior curve is much greater than in *gymnurus*, and the spiral twist is more pronounced, the root end of the teeth rotating more strongly inward. The posterior molar, both above and below, is much broader and heavier in *dolichocephalus* than in *gymnurus*, and the upper one is more strongly curved backward. The strong outward inclination of the roots of the end teeth of the series tends to keep the molars perpetually keyed up, preventing any spacing between the crowns. The destructive effects of the to-and-fro movement of the powerful planing machine are thus successfully offset.

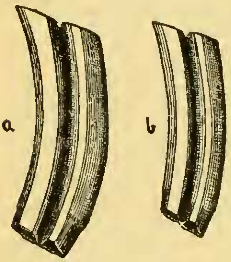
a b

FIG. 42.—Lower premolar showing difference in size and curvature according to whether the dominant jaw movement is to and fro or sideways. *a Macrogeomys dolichocephalus; b Platygeomys gymnurus.*

*What the lower premolar accomplishes by its massiveness and fixed position, the upper premolar accomplishes by its length and angle of implantation.

(2) *Effect on the proportions of the prisms.*—The breadth of the molar prisms with respect to their antero-posterior diameter is materially affected by the direction of the dominant movement of the jaw. This is readily seen in the crowns which are much more elongated transversely in those species in which the principal movement is obliquely transverse (*P. gymnurus* and others) than in those in which it is chiefly antero-posterior (*M. dolichocephalus* and others). In the former series the transverse diameter of the crown (of upper molars) averages two and one-half times the antero-posterior; in the latter, only two times.

(3) *Effect on the number and size of the enamel plates.*—Perhaps the most conspicuous and important of the differences in the molariform teeth, resulting from the direction of the dominant movement of the jaw, is in the number of the enamel plates on the upper intermediary molars. Two plates are invariably present in those forms in which the dominant movement is antero-posterior (genera *Geomys*, *Zygogeomys*, *Orthogeomys*, *Macrogeomys*, and *Heterogeomys*); while only one is present in those in which the movement is obliquely transverse (genera *Platygeomys* and *Cratogeomys*). In the latter case the enamel is restricted to the front face of the tooth, the posterior plate being obsolete, and the upper premolar resembles the molars in this respect, the posterior enamel plate being invariably absent.

ARRANGEMENT AND MODE OF OPERATION OF THE CUTTING BLADES.

The arrangement of the enamel plates and the direction of the dominant movement of the jaw in mastication present two widely different types in the animals under consideration. In one of these types the principal movement is obliquely transverse; in the other it is antero-posterior. They may be best considered separately.

(*a*) *Dominant movement of jaw obliquely transverse.*—When the upper tooth row of *Platygeomys gymnurus*, or any other species in which the dominant movement is obliquely transverse is examined as a whole, it is found to be made up of five flattened columns of dentine arranged seriatim one in front of another, and each faced in front with a vertical plate of enamel which projects a short distance beyond the crown (fig. 43 [1]). These five enamel plates are strongly convex forward and their curvatures are essentially parallel (fig. 44 [1]). An additional enamel plate covers the posterior face of the anterior pillar of the premolar and the isthmus connecting the two parts of this tooth; and the two lateral plates of the last upper molar may be considered as together forming another cutting plate, making seven in all in the upper series. Turning now to the opposing series—the lower molars—the opposite or complementary condition prevails, a curved enamel plate covering

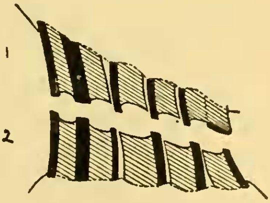

FIG. 43.—Longitudinal section of molariform teeth of *Platygeomys gymnurus* (diagrammatic). (1) Upper; (2) lower.

the posterior face of each of the five flattened columns of dentine (figs. 43^2 and 44^2). Two additional transverse plates complete the armament of the lower premolar, making seven in all, as in the upper series. It should be observed further that the concave sides of the five regular enamel plates face *backward* in the upper series and *forward* in the lower series. If now the two series are superimposed in the position they naturally assume in the mouth (fig. 45), and the lower series is moved obliquely forward and outward in the direction it normally takes when drawn by the masseter, the two sets of curved enamel blades come together like the opposing blades of seven pairs of shears working almost simultaneously, with this difference in favor of the teeth, that in addition to the antero-posterior closing movement the curved blades slide over one another laterally, thus giving the greatest possible advantage in slicing the hard roots and other unyielding substances on which the animals feed. The length of the blades gives a long sweep, while the curvature* insures the passage of

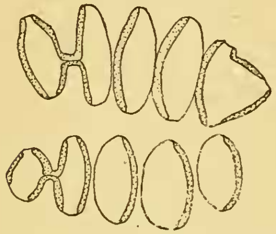

FIG. 44.—Crowns of molariform teeth of *Platygeomys gymnurus*. (1) Upper series; (2) lower series.

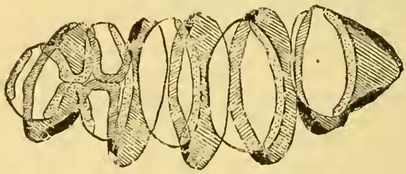

FIG. 45.—Superimposed molar series of *Platygeomys gymnurus* showing relations of enamel blades (light outlines lower series; dark, upper); *a* front end.

each particle of food against the cutting edges. The action is still further favored by the oblique truncation of the molar crowns and the peculiar method of suspension already described whereby the unyielding enamel blades gain an elasticity which gives them a shearing motion of the highest efficiency. The cutting is done during the obliquely forward movement of the mandible; the complementary movement is simply one of recovery and has no effect on the food.

The forward movement is evidently complex and apparently consists of three independent motions by which the mandible is shifted from side to side in a zigzag manner, as follows: (1) The mandible is carried obliquely forward and to one side until each of the enamel blades has completed a shearing cut against one of the blades of the upper series; (2) it is then carried obliquely forward in the opposite direction until each blade completes another cut; (3) it then turns again and the molar blades accomplish a third cut, leaving the upper and lower series

* The concave sides of the enamel blades move toward and over one another, inclosing the food in a rapidly contracting loop, the opposite sides of which meet and pass, leaving no chance for food to escape.

nearly in the same vertical plane. The lower series has been carried forward so that each tooth stands considerably in advance of the corresponding tooth of the upper series. A fourth movement, that of recovery, brings the mandible back to the starting point. The limit of the to-and-fro movement is nearly the same throughout the family *Geomyidæ* and is measured by the antero-posterior diameter of the crown of the premolar, which it slightly exceeds. When the jaws are at rest the front face of the lower premolar rests on or slightly behind the corresponding face of the upper premolar. When the jaw is drawn forward until the lower incisor strikes the posterior beveled face of the upper incisor, the lower premolar stands free from and wholly anterior to the upper. Hence, the thickness of the premolar is slightly less than the distance covered in the to-and-fro movement of the jaw. This being the case, it is easy to ascertain the number of cuts made by the enamel blades during each stroke of the jaw in mastication. By superimposing tracings of the upper and lower molar series (fig. 45) and moving the latter obliquely forward and outward under the former it appears that of the four cutting blades of the lower premolar the first is unimportant, the second glides over two cutting edges of the upper premolar during each stroke, the third and fourth cut against three edges each, and the single blade of each of the three true molars cuts over three enamel plates of the upper series (counting as one the two lateral plates of the last upper molar against which they cut), making seventeen cuts for each stroke of the jaw.

In a tame *Geomys lutescens* it was found (by actually counting the contractions of the temporal muscle) that the mandible makes 200 complete strokes a minute, which, at the rate of 17 cuts with each stroke, is equivalent to 3,400 cuts by a single pair of blades. This is the number of cuts made by the blades of a single ramus; but since the blades of both sides doubtless act simultaneously the number should be doubled, making a total of 6,800 cuts each minute!

The enamel plates are so spaced, by means of slight differences in the antero-posterior diameters of the upper and lower molars, that when the jaws are shut together and the movement of mastication takes place, only one pair of cutting edges comes into bearing at a time. The seven sets of blades, therefore, instead of cutting simultaneously, follow one another in rapid succession, one pair just completing its stroke as the next begins. By means of this delicate adjustment only one-seventh the power is required that would be necessary if all operated together.

If, in the animals having the above described shearing movement of the molars, a posterior enamel plate was present in the upper intermediary molars, or an anterior plate in the lower molars, the possession of such plates would obviously be a mechanical disadvantage, as they would not only be of no use but would be actually in the way. Hence, in the evolution of this specialized type one plate has been suppressed;

and the fact should be emphasized that the loss of a useless enamel plate is as clearly a sign of specialization as the development of an additional plate where needed. In the less specialized genus *Thomomys* both plates are always present (fig. 32, *b*).

(*b*) *Dominant movement of jaw antero-posterior.*—In the remaining groups the movement of the jaw is chiefly antero-posterior, the crowns of the teeth are more broadly elliptical, and enamel plates are present on both sides of the upper molars (figs. 46 and 47). In some genera the posterior plate, which is always thinner than the anterior, covers the whole hinder face of the tooth; in others it is restricted to the inner side, according to the exact axis of jaw movement. Whenever the ellipse is broad, and is so directed with reference to the enamel plates of the adjacent teeth that it presents a free edge *toward* the food that is being ground, this edge is invariably protected by a plate and cutting edge of enamel. Conspicuous illustrations of this law may be seen in the upper premolar of *Zygogeomys*, *Macrogeomys*, and *Heterogeomys*, and in the upper intermediary molars of *Zygogeomys*, in all of which the posterior enamel plate is restricted to the *lingual* side—the side impinged upon by the food. On the other hand, non-cutting edges protected by the enamel plates of adjacent teeth are better off without enamel of their own, because such enamel, if present, would not only be of no use, but would be actually in the way, as already explained.

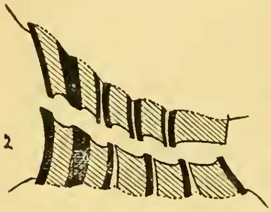

FIG. 46.—Longitudinal section of molariform teeth of *Macrogeomys dolichocephalus* (diagrammatic). (1) Upper series; (2) lower.

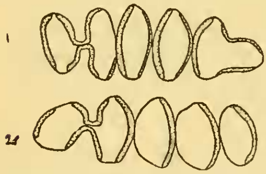

FIG. 47.—Crowns of molariform teeth of *Macrogeomys dolichocephalus*. (1) Upper; (2) lower.

By superimposing tracings of the upper and lower molar series of *Macrogeomys dolichocephalus* (fig. 48) and moving the lower backward and forward under the upper as nearly as possible in the way they are moved by the living animal, it is found that the cutting blades make nineteen cuts during each forward stroke of the jaw, as follows: The anterior plate of the lower premolar does not cut at all, or, if it cuts its action is so limited as to be of no particular consequence; the posterior plate of the anterior prism makes two cuts; the anterior plate of the posterior prism, three cuts; the posterior plate of the premolar and that of

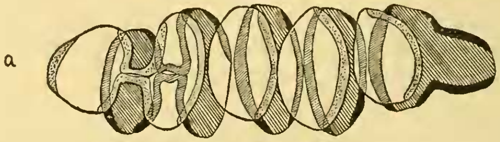

FIG. 48.—Superimposed molar series of *Macrogeomys dolichocephalus* showing relations of enamel blades. Light outlines, lower series; dark, upper. *a* front end.

the first molar make four cuts each; the second and third molars, three cuts each (counting the two lateral plates of the upper molar, against which m_3 acts, as if they were a single plate), making nineteen in all. During the return movement fourteen cuts are made, as follows: The second and third transverse plates of the premolar make two cuts each; the fourth, three; the first molar, three; the second and third molars, two each. The backward stroke is evidently less powerful and less effective than the forward stroke.

Since the teeth on both sides of the mandible cut simultaneously, the total number of cuts during each complete stroke will be double the number above mentioned, or 38 for the forward stroke and 28 for the backward stroke. Assuming that the number of complete strokes each minute is the same as in *Geomys lutescens*, namely, 200, the total number of cuts made each minute on the forward stroke would be 7,600, and on the backward stroke 5,600, making a grand total of 13,200 cuts each minute while the jaws are in active operation!

Stroke of the jaw.—There being no postglenoid process, the backward movement of the jaw is not interrupted until the condyle strikes the auditory bulla at the base of the tube of the meatus. When the condyle rests in this position and the molar series are in apposition, the front faces of the premolars above and below are in line. The forward movement of the jaw is stopped by the incisors and reaches its limit when the front face of the lower incisor strikes against the posterior face of the beveled edge of the upper incisor. When this happens the upper premolar usually rests on the back part of the first lower molar.

From the foregoing account it must be clear that the molars, which, considered as individual teeth, are simple elliptical tubes, lacking the complicated enamel patterns of the beaver, porcupine, and many other rodents, are so constructed that collectively they form one of the most powerful and highly specialized cutting and slicing machines known. The way the narrowly elliptical crowns are placed side by side flatwise, the hard projecting enamel blades alternating with surfaces of soft dentine, results in the production of a cutting and rasping apparatus equal if not superior to that possessed by those rodents and ungulates that have complicated enamel folds within the substance of the teeth. The obliquity of the crowns, whereby the upper and lower series are brought together in the arc of a circle, gives them remarkable power under the transverse movement of the jaws, while the way the teeth are suspended on vertical cushions, together with the angle of implantation and the double curvatures of their prisms, enables them to withstand the great strain to which they are subjected without danger of displacement and without injury to the tender pulps at their bases.

The secondary modifications of the skull resulting from the action of the muscles operating this wonderfully effective machinery are discussed elsewhere (pp. 104–107).

TREATMENT AND COURSE OF THE FOOD.

The circumstance that all the members of the *Geomyidæ* live underground has an important bearing on the kind of food habitually eaten, and is thus the remote cause of the special adaptations of the dental armature, and of the secondary cranial modifications necessitated thereby. The animals sometimes come to the surface and cut the stems and leaves of plants, which they draw into their subterranean tunnels, but in the main the choice of food is restricted to such parts of plants as may be found within the ground. The food therefore consists chiefly of tubers and roots, including the hard roots of trees and shrubs, the tough rootstalks of the mescal or agave, and the like. In dealing with these unyielding substances the animal gains one decided advantage—the roots on which it feeds are held firmly in place by the earth while pieces are chiseled off by the broad, trenchant cutting edges of the powerful incisors. In the case of certain relatively soft substances, such as potatoes, the lower incisors are sometimes used alone, both as a pry to dislodge pieces and as a scraper to scrape off thin slices, but as a rule both upper and lower incisors operate together. The principal function of the upper incisors seems to be to transfix the tuber and oppose the action of the lower while the latter do most of the work, moving rapidly backward and forward (and at the same time upward), until a piece of food is cut loose or sufficiently undermined so that it may be torn loose by a backward movement of the head while the teeth are held firmly together. The bit of food thus dislodged is either reduced in size by trimming—during which operation it is held between the large forefeet, the long claws turned inward toward one another—or is passed directly into the mouth or cheek pouches. The mouth proper, it should be remembered, is separated from the incisors by a furry partition which is directly in front of the molars. This diaphragm-like partition is of great service to the animal, keeping dirt and chips out of the mouth. When the food reaches the mouth proper the tongue and lips keep it between the teeth, where it undergoes the treatment commonly described as grinding. But in the highly specialized forms of the *Geomyidæ* no real grinding occurs—the whole process is one of cutting or slicing. The arrangement of the enamel plates that form the blades of the cutting machine has been already described in detail. In those species in which the principal movement of the jaw is antero-posterior the mechanism is essentially a *planing* machine, while in those in which the dominant movement is obliquely transverse it is a *shearing* or *slicing* machine. In either case the tough vegetable fibers composing the food are quickly reduced to a pulp, which is promptly passed on to the stomach for digestion.

MUSCLES THAT OPERATE THE CUTTING MACHINE.

The principal muscles concerned in the movements of the jaw are (1) temporal, (2) masseter, (3) internal pterygoid, (4) external pterygoid,

(5) digastric, and (6) transverse mandibular. Of these, by far the most important single muscle is the masseter.

The *temporal* muscle occupies the whole of the upper surface of the cranium behind the orbits, covering the parietal, squamosal, and posterior part of the frontal as far forward as the postorbital prominence. It arises from the flat upper surfaces of these bones and from the lambdoid and sagittal crests. The muscle is indistinctly divided into two parts—a superficial and a deep—which are not well defined in their origin. The fibers of the muscle as a whole converge anteriorly; those of the superficial part are inserted into the apex, posterior edge, and inner side of the coronoid process; those of the deep part play over the trochlear groove and at the margin of the orbit drop vertically downward and are inserted by a dense aponeurosis on the anterior edge of the basal half of the coronoid ramus from the plane of the molar crowns upward to a point slightly above the plane of the coronoid notch; posteriorly the muscle remains fleshy and covers the inner side of the coronoid ramus where its insertion extends downward to the bottom of the deep pit between the ramus and the posterior molar. The function of the temporal muscle is to shut the mouth, and in some species to draw the mandible slightly backward. Operating in connection with the digastric, it performs the backward stroke of the to-and fro movement of the jaw in the *dolichocephalic* series, the masseter producing the forward stroke.

The *masseter* is a large complex muscle and is by far the most important of the muscles concerned in the act of mastication. It is incompletely divided into three parts, which, from their principal sources of origin, may be described as the rostral or superficial, maxillary, and zygomatic parts.

(1) The *rostral* or superficial part arises by a long and dense aponeurosis from the outer side of the rostrum on the line of the premaxillo-maxillary suture, its upper border being immediately in front of the infraorbital foramen. It passes thence obliquely downward and backward, developing muscular fibers and spreading out posteriorly into a flat muscular band which is inserted upon the inferior crest of the masseteric fossa and the inferior surface of the mandible from the digastric crest posteriorly to the base of the angular process, its insertion being wholly fleshy. It is the most powerful muscle in drawing the jaw straight forward, and is aided in the *dolichocephalic* species by the zygomatic branch of the masseter.

(2) The *main body of the masseter* arises from the side of the anterior part of the maxilla and adjacent parts of the maxillary root of the zygoma. Anteriorly it slightly overlaps the posterior part of the premaxilla immediately below the top of the rostrum, where it forms a distinct crest continuous with the anterior edge of the maxillary root of the zygoma. The principal origin covers the whole of the anterior face of the vertically expanded zygomatic process of the maxilla, and

in addition a thin supplementary sheet takes origin from the posterior face of the same bony plate (within the orbital chamber). Posteriorly its origin is limited on the outer side by a thick aponeurosis, which is firmly attached to the inferior surface of the antero-external angle of the zygoma. The part within the orbit follows the inner face of the horizontal part of the zygoma all the way back to the glenoid ligament, to which its posterior fibers are attached. This part of the muscle is inserted on the outer side of the neck of the condylar ramus just above the incisor capsule.

(3) The *zygomatic part* of the masseter arises from the outer side of the horizontal part of the zygoma, its origin embracing the outer surface of the squamosal root of the zygoma and the outer side of the jugal below the oblique crest which marks the limits of its insertion above and in front. It arises also from the aponeurotic septum which separates it from the main body of the muscle. It is inserted upon the angular process of the mandible, its insertion covering the upper surface of this process from the incisor capsule outwardly to and over the head of the process, and also the under surface of the process to its very base, where its insertion becomes continuous with that of the main body of the muscle. Its function in *Geomys* proper and in all the *dolichocephalic* species is to draw the jaw forward. In the *platycephalic* species its insertion is carried so far outward by the great elongation of the angular process that it serves to move the jaw sideways, in which act it is aided by the pterygoid muscles.

The *internal pterygoid muscle* arises from the pterygoid fossa of the skull, which it completely fills. Passing directly outward and slightly downward, it is inserted into the pterygoid fossa of the jaw, where its line of attachment has developed a strong crest along the posterior edge of the angular process. Its function in *Geomys* proper and in all of the *dolichocephalic* species seems to be to bring the posterior end of the molar series firmly together when the jaw is shut. In the *platycephalic* species it aids the masseter in moving the jaw sideways.

The *external pterygoid* arises from the alisphenoid bone on the outer side of the root of the last upper molar and is inserted into the inner side of the neck of the condyle. Its function is evidently mainly the same as that of the internal pterygoid, though in addition it tends to move the mandible slightly forward.

The *digastric* arises from the paroccipital process and adjacent parts of the mastoid and audital bullæ, and is inserted on the digastric crest, which projects backward from the hinder part of the symphysis of the mandible. It is largely developed, its function being not merely to open the mouth, but, operating with the temporal, to draw the jaw strongly backward in the to and fro movement of mastication in the *dolichocephalic* series. Its action is very direct and powerful.

The *transverse mandibular muscle* connects the two halves of the lower jaw immediately behind the symphysis, where, in many species, there is

a distinct fossa for its lodgment. It must fulfill an important function in regulating the adjustment of the tooth rows during mastication.

MUSCLES OF THE CHEEK POUCHES.

I have not dissected the muscles of the cheek pouches, but they have been described by Dr. C. E. McChesney* and Prof. H. L. Osborn.† Dr. McChesney states that the aperture of the pouch is surrounded by a narrow delicate constrictor muscle, and that the long pouch itself, which extends back to the shoulder, is enveloped by a contractor muscle which seems to be a modified part of the *platysma myoides*. This muscle consists of two parts: (1) a retractor part, reaching from the extreme posterior end of the pouch backward over the muscles of the back and ending in a broad thin tendon which blends with the tendons of the superficial dorsal muscles, to be inserted into the spines of the three last lumbar vertebræ; (2) an anterior part which envelops the pouch proper. This latter is in turn subdivided into two parts—external and internal. The former covers the upper or outer portion of the pouch and is inserted into the maxillary bone (probably *pre*maxillary). The latter covers the inner and under sides of the pouch and is attached to the mandible, though the uppermost fibers join those of the former division, to be inserted on the upper jaw. Dr. McChesney states that the lower and inner surface of the muscle is thickest, the outer surface being thin and of little power.

Prof. Osborn describes the muscles of the pouch as follows: "There are three distinct sets of muscles; these are, first, a circular muscle that runs around the margin of the pocket in its outer bounding fold. This by its contraction would seem to purse the opening of the pocket. The second set of muscles are those that I will call the protractors of the pockets. These are two in number on each side. They are spread out in the skin of both the inner and outer posterior portions of the pockets, and their fibers converge forward to finally form somewhat definite bands. The outer of these is attached in the skin at the origin of the fold on the upper jaw. The other is attached to the lower attachment of the fold at the lower jaw. These two muscles thus surround the pocket, and their contraction pulls its recess forward to the opening of the vestibule. The third set of muscles are the retractors of the pocket. These arise funnel-wise from surface of the pocket, both on its inner and outer aspects, and they run backward and dorsally parallel to the fibers of the latissimus dorsi and totally free from the skin. They form a band three or four inches long and nearly an inch wide, and are finally inserted in the tendinous aponeurosis that covers the insertion of the latissimus dorsi and is attached to the neural spines of the anterior lumbar vertebræ. These by their action retract the pockets."

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* Bull. U. S. Geol. and Geog. Survey Terr., IV, No. 1, Feb., 1878, 214–215.
† Science, XXIII, Feb. 23, 1894, 102–103.

PRINCIPAL MUSCLES CONNECTING THE HEAD WITH THE NECK.

The *sterno-mastoid* muscle arises by a tendinous aponeurosis from the manubrium of the sternum and is inserted into the mastoid process of the squamosal immediately behind the auditory meatus.

The *cleido-mastoid* arises from the middle part of the clavicle and is inserted on the upper or dorsal aspect of the mastoid process of the squamosal immediately over or above the insertion of the sterno-mastoid. Its fibers are but little separated from those of the trapezius.

The *trapezius* muscle arises from the ventral surface of the outer third of the clavicle and the adjacent acromial process of the scapula and the spine of the scapula for its entire length; near the median line its fibers seem to be continuous with those of the median part of the *latissimus dorsi*. It is inserted on the lambdoid crest for its entire length, its outer edges being continuous with the insertion of the *cleido-mastoid*.

The *rhomboideus* lies immediately below the trapezius. It is much less extensive than the latter, but considerably thicker. It arises from the superior face of the spine of the scapula and the adjacent anterior part of the vertebral border of the scapula, and is inserted into the posterior face of the lambdoid crest immediately beneath the insertion of the trapezius.

ANALYSIS OF JAW MOVEMENTS.

Turning now from the consideration of the individual muscles to the study of the origin of the complex movements of the jaw in chiseling and slicing the food, even greater difficulties are encountered. The following attempt, therefore, is subject to correction.

(1) *The act of chiseling.*—From what has been said it appears that the act of chiseling is performed in essentially the same way in both the *platycephalic* and *dolichocephalic* members of the group, and that it is due to the joint action of the masseter and temporal muscles, the former being more effective than the latter.

The thin enamel edge of the upper incisors is used chiefly as an anchor to fasten the cutting machine firmly to the object operated upon, while the lower jaw plays back and forth like a drill in accomplishing the work. The exserted part of the upper incisors, therefore, is curved downward and inward, and the edge, which is very thin and sharp, is broken by one or more grooves, which enable it to penetrate hard substances more easily than if it were straight. The face of the lower incisor slopes strongly forward as well as upward and the axis of its movement in cutting must be obliquely forward and upward. The principal muscle concerned in chiseling is the *masseter*, which is aided by the *temporal*, and in some cases also probably by the *pterygoids*. The way the posterior part of the ramus of the mandible curves upward

in the arc of a circle has a highly important bearing on the efficacy of the action of the masseter, and has doubtless been molded into its present shape by this all-important muscle. The rostral part of the masseter is nearly horizontal; from its aponeurotic origin on the sides of the rostrum it spreads out posteriorly and is inserted broadly over the posterior curvature of the upturned ramus of the mandible, its action being to draw the mandible as a whole directly forward. The main body of the muscle is nearly vertical, but slopes slightly backward from its maxillary origin to its insertion on the outer side of the mandible; in contracting draws the jaw slightly forward and powerfully upward. In those species in which the zygomatic part of the masseter is nearly vertical instead of transverse this part of the muscle aids the rest in moving the jaw forward and upward. The masseter is aided still further by the temporal muscle, which, using the condyle as a fulcrum, moves the lower incisors upward.

(2) *The act of slicing.*—The act of slicing the food is performed in different ways in the two series of animals, being chiefly a to and-fro movement in the *dolichocephalic* species and a transversely oblique rotary movement in the *platycephalic* species. In the *dolichocephalic* species both the forward and backward movements are important, while in the *platycephalic* species the backward movement is merely one of recovery. In the *dolichocephalic* series, therefore, the forward movement produced by the masseter requires a powerful counter movement in bringing the jaw back. This is supplied, apparently, by the joint action of the digastric and the deep part of the temporal. The latter holds the teeth firmly together and draws the jaw slightly backward, while the digastric, contracting at the same time, pulls the jaw powerfully backward, the superficial part of the temporal, which is inserted on the coronoid process, preventing it from opening the mouth.

In the *platycephalic* series, as already stated, the principal movement is obliquely transverse, the jaw being drawn outward and forward. The muscles producing this action are the zygomatic part of the masseter and the pterygoids. It is probable that they are largely aided by the deep portion of the temporal, which is inserted into the pit on the outer side of the posterior molars. The fibers of this part of the temporal muscle being vertical, bring the teeth firmly together and draw the under jaw slightly outward, which movement, in connection with the angle of truncation of the crowns of the teeth, must result in the transverse rotary motion.

The mouth is opened by means of the digastric muscle, which is beautifully adapted to this end, its origin taking hold of the posterior part of the cranium on each side of occipital condyles, while its insertion is carried forward all the way to the symphysis of the jaw. The digastric does not appear to be assisted by any other muscle in performing its function of opening the mouth.

INFLUENCE OF THE MASSETER MUSCLE IN MOLDING THE SKULL AND MODIFYING THE TEETH.*

Throughout the *Geomyidæ* the masseter muscle has profoundly modified the form of the skull and the character of the teeth, and is largely responsible for the extraordinary cranial peculiarities that distinguish the several genera. Perhaps it would be better to say that slight differences in the direction of the principal movement of the jaw in grinding the food, which have proved an advantage to the animal, have by natural selection developed certain fibers or parts of the muscle at the expense of other parts, and that the differences thus originated have been perpetuated and intensified until the muscle has in turn molded the bones to which it is attached, and also those with which it comes in contact, thus altering the form and proportions of the cranium as a whole, and giving rise to extreme variations in the size, shape, and position of the zygomatic arch and in the development of the angle of the jaw. At least two very distinct types of skull have been established in this way—a broad or *platycephalic* type (pl. 3) and a narrow or *dolichocephalic* type (pl. 5).†

By contrasting the accompanying figures of representative skulls of these two types, with respect to the areas of attachment of the princi-

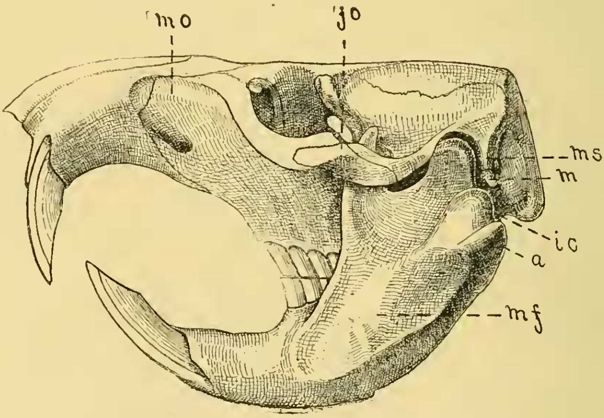

FIG. 49.—Side view of skull of *Macrogeomys dolichocephalus*, showing relations of mandible, and fossæ for attachment of muscles.

a Angle of mandible.
ic Incisor capsule.
jo Jugal origin of masseter.
m Mastoid process of mastoid bulla.
ms Mastoid process of squamosal.
mf Masseteric fossa.
mo Maxillary origin of main body of masseter.
mss Mandibular shelf (leading to angle in *Platygeomys gymnurus*).

pal parts of the masseter, the action of the muscle and its effects on the skull may be better understood. Without repeating the detailed

*For an important chapter on the general subject of the influence of the muscles in shaping the skull in the Rodentia, see Herluf Winge, Jordfundne og nulev. Gnavere fra Lagoa Santa, Minas Geraes, Brasilien, 1888, 103-110.

† These extremes in the form of the skull are brought about mainly by alterations in the superficial or outer parts, the fundamental structures and relations remaining very much the same in both, as shown by sectionized skulls (pls. 17 and 18).

descriptions already given under the head of the muscle (p. 99), it may be stated that the principal part of the masseter arises from the side of the maxilla in front of the zygomatic arch, and from the adjacent parts of the premaxilla and the maxillary root of the zygoma (fig. 49, *mo*). It is inserted upon the outer side of the mandible, and the area covered by its insertion—the *masseteric fossa*—extends from the angle to the plane of the front of the premolar (fig. 49, *mf*). Its origin, insertion, and relations are essentially the same throughout the group. The jugal part arises from the horizontal arm of the zygoma and is inserted upon the upper side and end of the angle of the jaw. Its size, form, area of origin, axis, and relative importance differ conspicuously in the various members of the series. In some forms it arises from the entire length of the horizontal part of the arch (fig. 50, *jo*); in others from the posterior part only (fig. 49, *jo*). The upper limit of its origin is marked by an oblique line and a change of direction in the outer face of the jugal.*

Effect on the skull.—In the long and narrow skulls, of which *Macrogeomys dolichocephalus* may be taken as a type, the great body of the

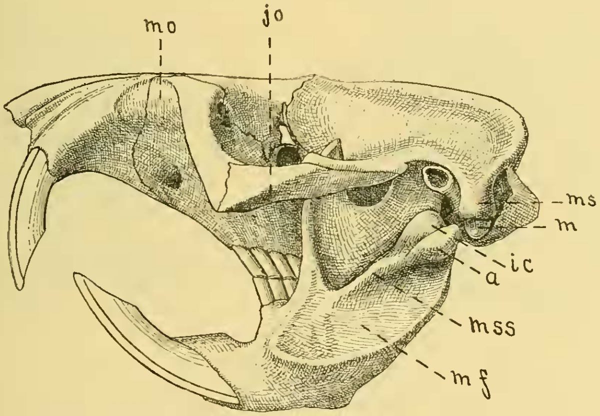

FIG. 50.—Side view of skull of *Platygeomys gymnurus* showing relations of mandible and fossæ for attachment of muscles. Lettering same as in fig. 49.

masseter is parallel to the side of the face, its function being to close the jaws firmly and draw the mandible forward. Its principal origin is maxillary, the jugal part being small and posterior to the plane of the middle of the orbit (fig. 49, *jo*). The resulting principal movement of the jaw is antero-posterior. The action of the muscle has narrowed the zygomatic arches, rounded off their anterior angles, and lifted them out of the way until the horizontal part of the arch is much nearer the

* Owing to the scarcity of material for dissection the masseter muscle itself has been actually examined in two forms only, namely, *Geomys bursarius* and *Macrogeomys dolichocephalus*. Its relations in these species, studied in connection with the well defined fossæ on the skull marking its origin and insertion, furnish a very good guide to its modifications and to the part it has played in producing the several types of cranium known in the group.

top of the skull in front than behind (fig. 49). The fibers of the jugal branch are nearly vertical, and are of little use except in drawing up the back part of the jaw. This may be seen from fig. 52: the muscle passes downward from the zygoma (*zy*) to the angle of the jaw (*a*).

In the broad and flat skulls, of which *Platygeomys gymnurus* may be taken as a type (fig. 50), the jugal branch of the masseter is largely developed, its function being to move the jaw sideways at the same time that the maxillary part brings the teeth firmly together. The resulting principal movement of the jaw is obliquely transverse. In producing this lateral movement the jugal branch is aided by the pterygoid muscles, but the latter must have played a very subordinate part in molding the skull. The jugal part of the masseter in the *platycephalic* series is not only of relatively large size, but the area of its origin is greatly extended (fig. 50, *jo*) and the axis of its fibers has become more nearly horizontal than vertical (fig. 54, *a* to *zy*). Its origin occupies the outer and inferior surface (and probably most of the inner surface also) of the horizontal part of the zygomatic arch for

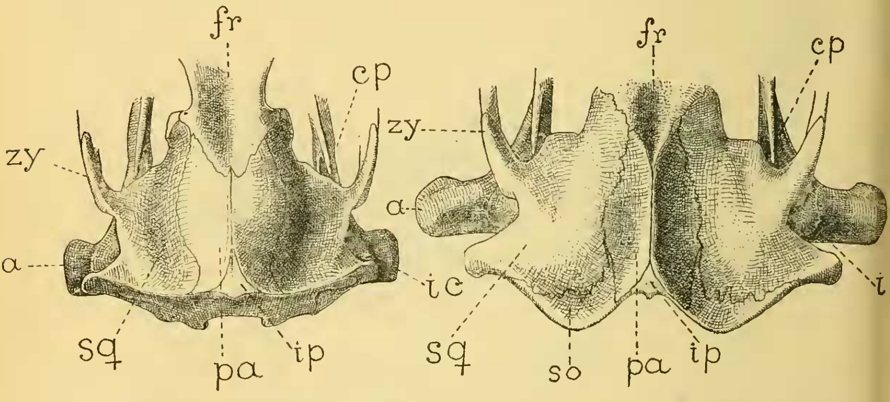

FIG. 51.—*Macrogeomys dolichocephalus.* FIG. 53.—*Platygeomys gymnurus.*

Posterior part of cranium from above, showing relations of mandible in place.

a Angular process of mandible.
cp Coronoid process of mandible.
ic Incisor capsule (covering root of lower incisor).
ip Interparietal.
fr Frontal.
pa Parietal.
so Supraoccipital.
sq Squamosal.
zy Zygoma.

its entire length, its anterior end being in front of the plane of the orbit. The action of this part of the masseter has drawn the zygomatic arch far outward and has pulled the anterior angle downward until the latter is further from the plane of the top of the skull than the posterior end of the arch. The angle is thus drawn down until it reaches four-fifths of the way from the plane of the top of the skull to the plane of the molar alveolus, overreaching and overarching the maxillary or principal part of the masseter muscle, which operates beneath it (fig. 50, which should be contrasted with fig. 49 of *Macrogeomys dolichocephalus*). The insertion of the muscle has produced an equally extraordi-

nary effect upon the shape of the under jaw. The sides of the jaw are not only spread widely apart in conformity with the great breadth of the skull, but in addition the fibers of the masseter that are inserted on the angular process have stimulated this process to push out sideways until it reaches off like a long arm at nearly a right angle to the axis of the skull (figs. 53 and 54, *a*).* The lengthening of this process was clearly necessitated in order to continue the effective action of the muscle. Furthermore, the segregation and specialization of the

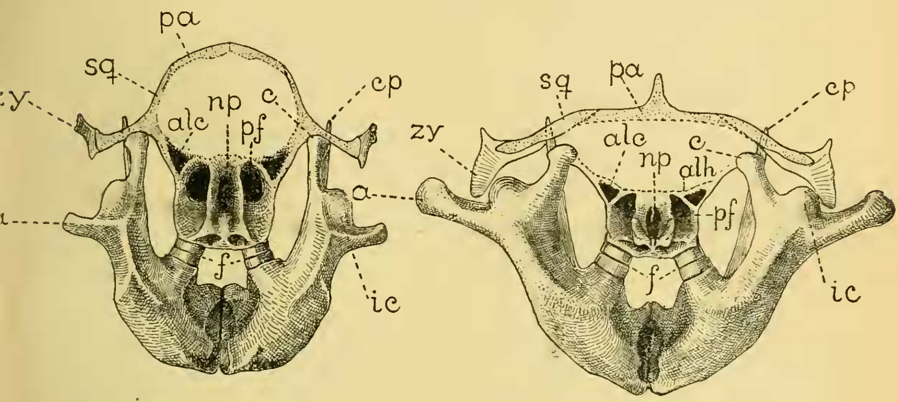

FIG. 52.—*Macrogeomys dolichocephalus*. FIG 54.—*Platygeomys gymnurus*.

Transverse vertical section of skull, with mandible in position, showing relations.

a Angular process of mandible.
alc Alisphenoid canal.
alh Horizontal arm of alisphenoid.
c Condyle of mandible.
cp Coronoid process of mandible.
f Angle of crowns of closed molars.
ic Incisor capsule (covering root of lower incisor).
np Narial passage.
pa Parietal.
pf Pterygoid fossa.
sq Squamosal.
zy Zygoma.

two parts of the masseter in the *platycephalic* series has resulted in the production of a long and well-defined horizontal shelf extending forward from the angle of the jaw to the base of the ascending ramus (fig. 50 *mss*). This shelf is totally wanting in *Macrogeomys dolichocephalus* and the other *dolichocephalic* forms in which the jugal part of the masseter is relatively unimportant and the principal movement of the jaw is fore and aft instead of transverse. The relations described may be seen to good advantage in the accompanying drawings (figs. 49–54).

Effect on the teeth.—While from the nature of the case it is clearly impossible to observe exactly what happens, either in the muscles or the teeth, during the act of mastication, it is at the same time permissible to draw certain inferences from the mechanical construction of the apparatus. In the case of the teeth, considered as the focus of the cutting machine, it has been already shown that two types exist, one

* In *M. dolichocephalus* the angle projects only 2½ mm. beyond the plane of the zygoma (fig. 52), while in *P gymnurus* it projects 10½ mm.

in which the crowns of the upper intermediary molars are broadly elliptical and bear two enamel plates (one on each face); the other in which the crowns are narrowly elliptical and bear only one enamel plate (which is on the anterior face). It has been shown further that the presence of two enamel plates is always correlated with an antero-posterior movement of the jaw, and that the presence of a single plate is always correlated with an obliquely transverse movement of the jaw. A careful study of the cutting blades in each instance shows that an antero-posterior movement is accompanied by a to-and-fro planing action in which two enamel blades are serviceable; and that a transversely oblique movement is accompanied by a lateral shearing action in which only a single blade can be used. In accordance with the well-known law that useful structures are preserved and useless structures suppressed, it is logical to infer that the direction of the dominant movement of the jaw has determined the presence or absence of the posterior enamel plate; and since the movement of the jaw is controlled by the masseter muscle, it is evident that the number of enamel plates on the upper intermediary molars may be traced back to the influence of this muscle.

In the course of the evolution of the two types just described it seems evident that as soon as the principal movement of the jaws in the line leading to *Macrogeomys dolichocephalus* came to be fore and aft it was settled that the form of the posterior part of the cranium should be narrow; that the angle of the under jaw should be shortly truncate; that the grinding teeth should be broadly elliptical, and that the posterior enamel plate of the upper series should be retained; and when the principal motion of the jaw in the ancestors of *Platygeomys gymnurus* came to be obliquely transverse, from that moment it was predetermined that the hinder part of the skull should be broadly expanded; that a long arm-like process should spring from the angle of the jaw; that the grinding teeth should be transversely flattened, and that the posterior enamel plate of the upper series should disappear.

CHAPTER IV.

SYSTEMATIC DESCRIPTIONS OF GENERA AND SPECIES.

Genus GEOMYS Rafinesque, 1817.

Pls. 1, 7, 9, 12; pl. 15, figs. 11 and 12; pl. 17, fig. 3; pl. 18, fig. 1; pl. 19, fig. 3, and text fig. 55; maps 1 and 4.)

Type *Mus tuza* Ord, 1815, from AUGUSTA, GEORGIA. (=*Geomys pinetis* Raf., 1817).

Geomys Rafinesque, Am. Monthly Magazine. II, No. I, Nov., 1817, 45. Type *G. pinetis* Raf. (=*Mus tuza* Ord, 1815), from pine barrens near Augusta, Ga.
Diplostoma Rafinesque, Ibid. 1817, 44–45.
Saccophorus Kuhl, Beiträge zur Zool., 1820, 65–66.
Pseudostoma Say, Long's Expd. to Rocky Mts., I, 1823, 406.
Ascomys Lichtenstein, Abh. Akad. Wiss. Berlin (1822), 1825, 20. fig. 2.

Dental characters.—Upper premolar with three enamel plates (the posterior absent). Upper pm decidedly longer than lower (in the other genera they are subequal); shaft of upper pm decidedly concave forward, except in a single species (*G. lutescens*). First and second upper molars with two enamel plates each, the posterior complete; posterior curvature of m^1 and anterior curvature of m_2 hardly apparent.

Last upper molar a single subcylindric or subtriangular prism without lateral sulcus on either side (and consequently without heel); outer enamel plate normally straight; inner and outer plates commonly subequal, or outer somewhat shorter, both reaching posterior face of tooth. Upper incisor strongly *bisulcate* (fig. 22^2 and 22^3; pl. 15, figs. 11 and 12).

Cranial characters.—Skull simple, without any very striking external characters. Orbitosphenoids small and narrow, not reaching alisphenoids (pl. 17, fig. 3); sphenoid fossæ correspondingly elongated, reaching forward to orbital plates of frontal; alisphenoids short posteriorly, ending on floor of brain case about on plane of front ends of audital bullæ; pterygoids large, always forming more than half of the palatopterygoid extensions; mesethmoid plate large, somewhat rectangular, much longer than high, and wholly superior to vomer (not dipping down between vomerine wings as in *Pappogeomys*); endoturbinals collectively forming a quadrate plate, the anterior border of which is parallel to the cribriform plate (pl. 19, fig. 3); first endoturbinal rounded and only slightly expanded anteriorly, its inferior border falling (as the os planum) in the front of the others and articulating with the anterior third of the internal vertical plate of the maxilla—the os planum thus extending anteriorly in front of the lower endoturbinal much further than the length of the latter.

In the elongated skulls of *Geomys bursarius* and *tuza* the lower part of the sphenoidal fissure, on the floor of the orbit, differs from its condition in any of the other groups (fig. 55). In all of the others a fenes-

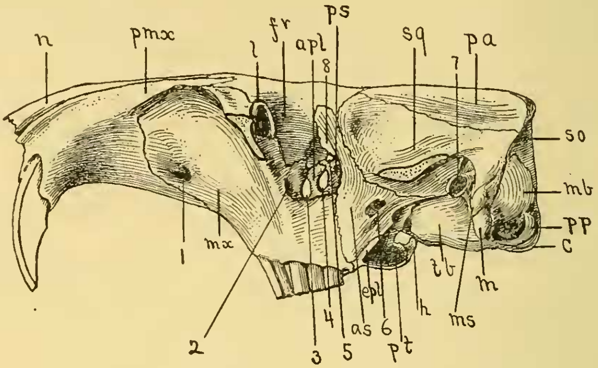

FIG. 55.—Side view of skull of *Geomys bursarius* from outside, zygomatic arch sawed off to show bottom of orbit. Animal a fully adult ♂, from Knoxville, Iowa. (This figure should be compared with the corresponding view of *Cratogeomys merriami*, fig. 4.)

1. Infraorbital foramen.
2. Posterior (orbital) opening of infraorbital canal.
3. Vacuity in front of presphenoid and ascending wing of palatine.
4. Vacuity in presphenoid, behind ascending wing of palatine.
5. Optic foramen (in orbitosphenoid bone).
6. Foramen rotundum and foramen ovale (which have here coalesced).
7. External auditory meatus.
8. Sphenoidal fissure (upper part).

apl. Ascending wing of vertical plate of palatine.
as. Alisphenoid.
c. Condyle of exoccipital.
epl. External pterygoid plate of palatine bone.
fr. Frontal.
h. Hamular process of pterygoid bone.
l. Lachrymal.
m. Mastoid process of mastoid bulla.
mb. Mastoid bulla.
ms. Mastoid process of squamosal.
mx. Maxilla.
n. Nasal.
pa. Parietal.
pmx. Premaxilla.
pp. Paroccipital process of exoccipital.
ps. Presphenoid.
pt. Pterygoid.
so. Supraoccipital.
sq. Squamosal.
tb. Tympanic or audital bulla.

trum (fig. 4,[6])* penetrates the interorbital septum, which at this point consists of the presphenoid only. In *Geomys bursarius* and *tuza* the basal part of the sphenoidal fissure is unusually broad, and the septum at

* In some cases, particularly in *Orthogeomys* and *Zygogeomys*, this fenestrum is subdivided into two or even three parts, but they all invariably penetrate the presphenoid; they are never in front of it.

its bottom, which here consists of both palatine and presphenoid, is perforated by two fenestra, which look completely through the skull from orbit to orbit. The posterior is the usual opening in the anterior part of the presphenoid (fig. 55,[4]); the other is in front of the presphenoid and is bounded anteriorly by a process from the maxilla, which here rises to join the frontal (fig. 55,[3]). Hence in *Geomys bursarius* there are three openings in the bottom of the orbital fossa, arranged seriatim, one in front of the other. The first is the posterior outlet of the infraorbital canal (fig. 55,[2]); the second is the vacuity here mentioned, which penetrates the skull in front of the presphenoid (fig. 55,[3]); the third is the usual fenestrum in the anterior part of the presphenoid (fig. 55,[4]). The opening in front of the presphenoid is completely surrounded by the maxilla and ascending wing of the palatine—the former bounding it in front, the latter behind—for the ascending wing of the vertical plate of the palatine (fig. 55, *apl*) here rises along the front of the presphenoid between the two fenestra in question and articulates with the maxilla, the orbital plate of the frontal, and the orbitosphenoid. (See also fig. 10.)

The condition here described has not been observed except in the elongate skulls of *Geomys bursarius*, *tuza*, and *personatus*, and is imperfectly developed in the latter. It reaches its highest development in *Geomys bursarius*, and does not occur in the closely related *G. lutescens*, which has a short skull. A condition simulating it sometimes exists in *Orthogeomys*, in which there are several (usually two or three) small perforations in the anterior part of the presphenoid, but the relations of the ascending wing of the palatine are not the same. Very young specimens of *Cratogeomys* resemble the adult of *Geomys* in the presence of a fenestrum in front of the presphenoid and ascending wing of the palatine, but the fenestrum disappears as the animal matures, a vestige of it remaining as a foramen (on each side), which opens from the floor of the orbit obliquely forward and downward into the narial passage.

The genus *Geomys*, even as here restricted, comprises three series or groups of species: (1) the *texensis-breviceps* series, (2) the *tuza* series, and (3) *Geomys busarius*.

(1) The *texensis-breviceps* series inhabits Texas, Louisiana, Arkansas, and the Great Plains, and includes eight species and subspecies, as follows: *arenarius*, *texensis*, *lutescens*, *breviceps*, *breviceps sagittalis*, *breviceps attwateri*, *personatus*, and *personatus fallax*. Most of these, particularly *arenarius*, *texensis*, and *breviceps*, are small generalized forms suggesting relationship with *Thomomys* and *Pappogeomys*. Indeed, these animals are very much alike in many ways and the skulls agree in general form, lightness, in the small rounded brain case, slender and nearly parallel zygomata, narrow pterygoids, and many other characters, though differing conspicuously in the teeth. It seems evident that they are but little removed from the trunk line of the group, and that both the *tuza* and the *bursarius* series are offshoots from the *brevi-*

ceps stem. *Geomys breviceps* seems to be the central or parent type from which three widely different species originated, *tuza* on the east, *bursarius* on the north, and *lutescens* on the west. To the eastward only a narrow gap separates the range of *breviceps* from that of *mobilensis* of the *tuza* series, which, though specifically distinct, was evidently derived from the *breviceps* stock. Still further east *mobilensis* passes in to *tuza*. On the west *breviceps* shades toward and probably will be found to intergrade with *lutescens*. On the north only a narrow hiatus separates it from *bursarius*, the most specialized type of the series. Specimens of *bursarius* from southern Missouri suggest that the gap between it and *breviceps* is not very wide; if continuity of range between the two forms is anywhere found this gap may be bridged even at the present time (see map 4).

(2) The *tuza* series inhabits the South Atlantic and Gulf States south of the Savannah River and east of the Mississippi (mah 4, A), and comprises three forms, *tuza*, *tuza mobilensis*, and *tuza floridanus*. They are locally known by the singularly inappropriate and misleading name 'Salamander.' The members of the *tuza* series agree among themselves and differ from the remaining forms of the genus *Geomys* in having longer and more naked tails, and in numerous cranial characters. The shape of the skull in pofile is decidly convex, the rostrum long and decurved, the nasals long and slender and constricted in the middle, giving them a somewhat hour-glass shape. The interparietal is permanently distinct from the supra-occipital and is normally much larger than in any of the other groups, though in *G. mobilensis* it is nearly obliterated in old age by the encroachment of the ridges that unite to form a sagittal crest.

The *tuza* group differs not only from *bursarius*, but from all other known members of the family, in the disproportionate length of the upper premolar in relation to the other molariform teeth. It is merely double the length of m^3. The lower premolar is much shorter, particularly in *floridanus*.

(3) *Geomys bursarius* inhabits the upper Mississippi Valley (map 4, B) and stands alone at the end ot the northern branch, just as *Geomys tuza* occupies the end of the eastern branch of the restricted genus *Geomys*. The skull is elongated and angular, the frontal compressed between the orbits, the palatopterygoids broadly lingulate, and the sagittal crest high; but the most important departure from its allies is found in the anterior part of the cranio-facial axis, and consists mainly in the broad articulation of the ascending wings of the palatine bones with the horizontal shelf of the orbitosphenoids, and in the presence of a fenestrum looking completely through the skull in front of the presphenoid. *G. bursarius* presents the extreme of differentiation occurring in the bisulcate series inhabiting the United States.

The following brief tabular statement of some of the cranial characters of the three members of the *tuza* group may facilitate the identification of specimens:

Differential cranial characters of the members of the tuza group.

	Mobilensis.	Tuza.	Floridanus.
Temporal impressions	United in a sagittal crest	Distant	Distant.
Frontal (interorbitally)	Very broad	Narrow	Narrow.
Ascending branches of premaxilla	Moderate	Moderate	Very broad and blunt.
Palatopterygoid	Narrow, sides parallel	Lingulate-cuneate	Lingulate cuneate.
Audital bullæ	Small	Small	Large.
Interparietal	Deeply notched posteriorly	Not notched	Not notched.

KEY TO SPECIES AND SUBSPECIES OF GEOMYS BY CRANIAL AND DENTAL CHARACTERS.

[Based on skulls of adult males only.]

(1) JUGAL *equal to or shorter than basioccipital* (measured from condyle).
  a^1 *Sagittal crest present.*
    b^1 Zygomata strongly angular (standing out at right angles); jugal broadly rounded anteriorly.
      Size large; audital bullæ normal .... *personatus*
      Size medium; audital bullæ short and swollen (almost subglobular) . *fallax*
    b^2 Zygomata rounded; jugal narrow anteriorly; size small .... *sagittalis*
  a^2 *Sagittal crest absent.*
    Temporal ridges prominent; squamosal arm of zygoma ending in a knob .... *arenarius*
    Temporal ridges not prominent; squamosal arm of zygoma not ending in a knob .... *texensis*
(2) JUGAL *longer than basioccipital* (measured from condyle).
  c^1 *Sagittal crest strongly developed*—long and high; size largest ...... *bursarius*
  c^2 *Sagittal crest feebly developed or absent;* size medium or small.
    d^1 Nasal bones hour-glass shaped; strongly constricted near middle.
      e^1 Temporal impressions uniting in sagittal crest .... *mobilensis*
      e^2 Temporal impressions not uniting in sagittal crest.
        Audital bullæ small; not swollen; nasals broad posteriorly ..... *tuza*
        Audital bullæ large, swollen; nasals narrow posteriorly ... *floridanus*
    d^2 Nasal bones not hour-glassed shaped; slightly or not constricted near middle.
      f^1 Frontal strongly depressed interorbitally; zygomata broadly rounded; nasals very narrow posteriorly, notched behind . *breviceps*
      f^2 Frontal slightly or not depressed; zygomata angular, strongly divergent anteriorly.
        Temporal ridges prominent, divergent anteriorly; nasals abruptly narrow and convex posteriorly .... *attwateri*
        No temporal ridges; temporal impressions parallel or meeting in sagittal ridge; nasals truncate or emarginate posteriorly .... *lutescens*

GEOMYS TUZA (Ord).

(Frontispiece and pl. 7, fig. 1; pl. 13, fig. 9; pl. 15, fig. 12.)

Mus tuza Ord, Guthrie's Geog., 2d Am. ed., II, 1815, 292 (based on Mitchill's "undescribed little quadruped of Georgia"—see *postea*).

Geomys pinetis Rafinesque, Am. Monthly Magazine, vol. II, No. 1, Nov., 1817, 45 (type of genus *Geomys*).

Undescribed little quadruped of Georgia, Mitchill, New York Medical Repository, V, 1802, 89. (Descr. orig. on which the name *Mus tuza* of Ord was based.)

Hamster of Georgia, Anderson, 2d Am. from 8th London ed. of Bewick's Hist. of Quadrupeds, 1848,* 326 (accompanied by figure with cheek pouches properly turned in).

Type locality.—Pine barrens near AUGUSTA, GEORGIA.†

Geographic distribution.—Pine barrens of Georgia (and probably northern Florida also), within the Austroriparian faunal area (map 4).

General characters.—Size medium or rather large; tail long and naked; feet moderately well haired; a small naked pad on end of nose.

Color.—Upper parts cinnamon brown, strongly tinged with fulvous in fresh pelage; only a faint trace of darker median dorsal stripe; under parts dull ochraceous buff; hairs of feet whitish.

Cranial characters.—Skull rather large and angular (Pl. 7, fig. 1), its upper surface convex in profile (due in part to the strongly decurved rostrum and in part to the absence of sagittal crest); zygomata divergent anteriorly, the maxillary root sloping strongly backward; temporal impressions never uniting in a sagittal ridge, but forming permanent temporal ribs, which in the males are elevated on both sides and separated by an interspace or sagittal area 3 to 4 mm. in width. In the females the interspace is broader and usually thickened so that it is flush with the top of the temporal impressions. Interparietal very large and broad. The frontal is narrow interorbitally; postorbital prominences marked; palatopterygoids lingulate-cuneate, the base slightly or not excavated on outer side; audital bullæ small, normal; basioccipital strongly wedge-shaped, truncate anteriorly.

Skulls of *G. tuza* may be distinguished from those of *mobilensis* by the presence of distant temporal ridges instead of a sagittal crest; by the narrow frontal (interorbitally); by the lingulate-cuneate (instead of narrow strap-shaped) palatopterygoids, and by the very large interparietal which is not notched behind (fig. 6 *c*). Skulls of *tuza* differ from those of *floridanus* in much narrower ascending branches of premaxilla, broader nasals posteriorly, more strongly wedge-shaped basioccipital, and much smaller audital bullæ. The relationship with *floridanus* is much closer than with *mobilensis*. The profile of the top of the skull is more convex than in either of the others.

Measurements.—*Average* of ten males from type locality (Hollywood, Georgia, 12 miles south of Augusta): Total length, 269; tail vertebræ, 89.5; hind foot, 34.4.

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* The copy cited by Coues (Monographs of N. Am. Rodentia, 1877, 615 footnote) has the same pagination, but a somewhat different title page (different publisher) and is not dated. The eighth London edition of Bewick was published in 1824. The only mammals described in the American reprint not in the original are the grizzly bear, hamster of Georgia, and mammoth.

†The type specimen was sent Dr. Mitchill from Augusta, Ga., in July, 1801, by Josiah Meigs, president of the University of Georgia. In the letter that accompanied the specimen Mr. Meigs said: "For the space of about 100 miles, between Savannah and Augusta, the land on each side of the road is almost covered by the heaps of loose earth raised by it."—New York Medical Repository, V, 1802, 89.

Average of nine females from same place: Total length, 249; tail vertebræ, 82; hind foot, 32.

For cranial measurements see Table C, p. 208.

Specimens examined.—Total number 32: twenty from type locality, Hollywood, 12 miles south of Augusta, Georgia; and twelve from Butler, Georgia, (latter not typical).

General remarks.—Specimens from Butler, near the western border of Georgia, are intermediate between *tuza* and *mobilensis*. In color they resemble the latter, while in cranial characters they are nearer the former.

It is an interesting fact that the first description of this species—and not a bad description either, considering it was written nearly a century ago—was from the pen of a member of Congress, the Hon. John Milledge, Representative from Georgia. It was published by Dr. Mitchill in the New York Medical Repository in 1802 (vol. v, p. 89), and runs as follows: "One of the little animals that burrows in the pine land, only known in Georgia, was caught by Mr. Stephen Pierce, living midway between Savannah and Augusta. Its body is of the length and thickness of a common-sized rat, and of the same color: the head between that of a rat and a mole, with small whiskers and short snout: the tail without hair, but shorter than that of a rat: the fore feet like those of a mole, with nails near an inch long: the hind feet like those of a rat, but the nails not of the same length, each foot having five claws: very sparkling small eyes: also short ears: teeth like a squirrel, and full as long. On both sides of the jaw, externally, are sacks or wallets, where it deposits its food, and each will contain as much as can be put in a large tablespoon. Little or no fur, and the hair of the length of a wood rat. The whole face of the pine country is covered with little mounds made by this animal, of the circumference of a peck, and from 6 to 8 inches high. It is by no means active, but remarkably fierce. No common wooden place of confinement can hold it long, as it gnaws its way out. It lives entirely on roots, and is very fond of the sweet potato, and often proves injurious to the planter by getting under his stacks. It appears to move nearer the surface in the spring and fall than at any other season. It is surprising, that though the work of this creature is seen throughout the country, in the region of the long-leaf pine, and in that region only, yet such is its skill in burrowing, and acuteness of hearing, that there is no animal in all our State so seldom caught or seen."

GEOMYS TUZA FLORIDANUS (Aud. and Bach.).

(Pl. 7, figs. 3 and 4; Pl. 10, fig. 1; Pl. 14, fig. 16.)

Pseudostoma floridana Aud. and Bach., Quadrupeds of North Am., Vol. III, 1854, 242–245.

Geomys tuza Goode (not Ord), Powell's Report Colorado River, 1875, 281–285 (habits).

Type locality.—ST. AUGUSTINE, FLORIDA.*

*Audubon and Bachman did not discriminate between the Georgia and Florida animals, but all of their Florida specimens came from St. Augustine.

General characters.—Similar to *G. tuza*, but much darker in color; fore feet larger; tail slightly more hairy; differs also in cranial characters.

Color.—Upper parts dull sooty-plumbeous, becoming cinnamon-drab on the sides; under parts plumbeous, more or less washed with buffy; an irregular white patch under chin and throat.

Cranial characters.—Skull long, with very angular zygomatic arches, much as in *tuza* and *mobilensis*. *G. floridanus* differs from *G. tuza* in broader and blunter ascending branches of premaxilla, narrower nasals posteriorly, somewhat broader jugals anteriorly, more rectangular (less strongly wedge-shaped) basioccipital, and much larger audital bullæ; from *mobilensis* in much larger audital bullæ, narrower frontal, less spreading and more depressed arches, much broader ascending branches of premaxilla, less flattened brain case, lingulate-cuneate instead of narrow palatopterygoids, and in the presence of temporal ridges instead of a sagittal ridge. The angular process of the mandible is much less deeply notched at base anteriorly. In *G. floridanus* the interspace between the two grooves of the upper incisor is broader than in either *tuza* or *mobilensis*, and the head of the jugal is more deeply mortised into the maxillary arm of the zygoma.

Specimens examined.—Total number 25, from the following localities in Florida: Chattahoochee, 2; Pomona, 4; Gainesville, 1; San Mateo, 6; Tarpon Springs, 12.

Measurements.—Average of three males from San Mateo, Florida (measured in flesh by Dr. W. L. Ralph): Total length, 288; tail vertebræ, 94; hind foot, 35.5. Average of three females from same locality: Total length, 235; tail vertebræ, 77; hind foot, 33. For cranial measurements see Table C, p. 208.

General remarks.—The foregoing description has been drawn up from specimens from San Mateo, Putnam County, Florida,* only 25 miles from St. Augustine, the type locality of the species. Specimens from further south on the peninsula are somewhat different.

The best and almost the only authentic account of the habits of this species is from the pen of the eminent director of the U. S. National Museum, Dr. G. Brown Goode, by whom it was contributed to Coues' monographic paper on the group, published in 1875.† Dr. Goode kept a number in confinement for several weeks and was thus enabled to make the following interesting observations on their habits. He says: "They may easily be confined in a wooden box, with sides 8 or 10 inches high, having dry sand 2 or 3 inches deep on the bottom. No cover is necessary; I have never seen one look up from the earth, and have

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*These specimens were kindly presented to me by Dr. W. L. Ralph, of Utica, New York, who collected them himself and measured them in the flesh.

†Abstract of results of a study of the genera *Geomys* and *Thomomys*. Powell's Expl. Colorado River, 4°, 1875, 215–285. Addendum B.—Notes on the "Salamander" of Florida, by G. Brown Goode, 281–285.

rarely known them to attempt to escape. They require no water, and no food except sweet potatoes. A single potato of moderate size will feed a salamander for three days.

"The senses of sight and hearing seem in them to be very dull. An object may be held within a short distance of their eyes without attracting their attention; but the moment one is touched, he turns with a jump, snapping fiercely, much to the detriment of fingers which may be near. If two are confined in the same cage, the one does not seem aware of the presence of the other, unless they accidentally come in contact. Their eyes are small, dull, and without expression. Their sense of smell I judge to be very delicate, from the manner in which they approach the hills of potatoes. Their motions are surprisingly quick and energetic, their activity never ceasing from morning to night.

"They are very pugnacious, and a rough-and-tumble combat between two vigorous males would seem terrific, if their size could be magnified a few diameters in the eye of the spectator. Every muscle of their compact, elastic, stout bodies is brought into action, and they plunge and bite with wonderful ferocity. A battle is usually followed by the death of one or both. I have examined them after death and found the whole anterior part of the body bruised almost to the consistency of paste, the bones of the legs crushed in four or five places. When two come together in the cage, their salutation is a plunge and a bite.

"I watched their burrowing with much interest. They dig by grubbing with the nose and a rapid shoveling with the long curved fore paws, assisted by the pushing of the hind feet, which remove the dirt from beneath the body and propel it back with great power a distance of 8 or 10 inches. When a small quantity of earth has accumulated in the rear of the miner, around he whirls with a vigorous flirt of the tail and joining fore paws before his nose, he transmutes himself into a sort of wheelbarrow, pushing the dirt before him to a convenient distance, and repeating the act until the accumulation is removed, then resuming his mining. Any root or twig which blocks his way is quickly divided by his sharp chisel-teeth. * * * The direction of the burrows may easily be traced by the loose hillocks of white sand which are thrown up along the line at intervals of 3 or 4 feet. These are the 'dumps' made by the burrower in throwing out his refuse accumulations. Each consist of about a peck of loose sand, and, by the casual observer, might easily be mistaken for an ant-hill. No opening is visible, but by digging under the hill a hole is found, the mouth of the adit to the main tunnel, which may be 3 feet below the surface if made in cold weather, but perhaps not more than 6 inches if in summer. One of the mounds is thrown up in a very few moments. I have seen 30 raised in a single night on the line of one tunnel; this would represent nearly 100 feet of tunneling. I have seen 150 in one continuous row raised in about two days; this would make between 400 and 500 feet of burrow completed in that short time, apparently by one little animal, an amount

of work which may seem incredible to one who has not watched the restless movements of these animated plows, which are seemingly as well adapted for piercing the sand as birds are for cleaving the air. The burrows are about $2\frac{1}{2}$ inches in diameter. * * * The nests are large chambers, 1 or 2 feet from the main tunnel, with which they are connected by side passages, which leave nearly at right angles. Here the miners lay up a supply of provisions and the chambers are often found to contain a half bushel of sweet potatoes cut up into chunks as large as peach stones, and of convenient size to be carried in the pockets. * * * In these side chambers the salamanders rear their young, building a nest of grass, pine needles, and live-oak leaves. I found them breeding in April."

Dr. Goode remarks that the name 'salamander,' by which the species is universally known in the South, "may allude to the safety enjoyed by these little animals in their subterranean abodes at the time of the devastating fires which sometimes consume the pine forests. After such a conflagration has passed over their heads, destroying every other kind of life, they are seen at work among the ashes, very good types of the salamander of fable."

Mr. Morris M. Green, who obtained specimens for the Division at Pomona, Putnam County, Florida, in June, 1889, furnished the following notes respecting their habits: "The hills of the 'salamander,' as the Florida *Geomys* is called, are abundant in the pine woods and clearings, on rather low and moist land. Their tunnels were from 4 to 24 inches below the surface; the hills were thrown up at intervals of from 2 to 6 feet, and contained about a peck of dirt each. The night and early morning seemed to be their favorite time for working. It is very easy to trap a 'salamander' when fresh mounds are found. By sweeping to one side the heaps of dirt, traces of the hole through which the earth was brought and its direction can be easily found. A minute's work with the spade will usually expose the tunnel lying to one side of the hill. Place a steel trap in the tunnel, and cover up the breach with a piece of pine bark or some palmetto 'fans.' If the breach is left open, the animals will carry dirt to shut out the light, and thus clog the trap, whereas if the opening is closed they will step in the trap and are caught. A break is often repaired within half an hour, or it may be left for nearly a day. In mending an opening it is astonishing how compactly the earth is packed; in one case an animal closed an opening so securely that the tunnel could not be found at all until another shaft was sunk in search of it.

"A 'salamander' caught in a trap is a picture of fury and spite, biting at everything within reach of its jaws, and sometimes breaking its front teeth in venting its rage on a trap.

"In the cheek pouches of one were some pieces of pine roots, and some grasses were found in the tunnels. The animals do serious injury to orange and pear trees by gnawing the roots. Sometimes the roots

are gnawed off so completely that the tree can be pushed over with one hand. They also feed on sweet potatoes. But when an animal enters a garden or an orchard, and betrays itself by throwing up hills, there is no excuse for not ridding the place of it, as it may be easily caught in a steel trap. It is claimed that the 'salamander' works near the surface from September to March, retiring deeper in the ground during the hot season."

GEOMYS TUZA MOBILENSIS subsp. nov.

(Pl. 7, figs. 2, 5, and 6; pl. 10, fig. 2; pl. 14, fig. 15; text fig. 6, *f* and *g*.)

Type from MOBILE BAY, ALABAMA. No. $\frac{33988}{46023}$ ♂ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected April 26, 1892, by Russell J. Thompson. (Original No. 50.)

Geographic distribution.—Southern Alabama and adjacent part of northwest Florida, within the Austroriparian zone (map 4).

General characters.—Similar to *G. tuza*, but somewhat smaller, and much darker in color; tail shorter, nearly naked; feet scant haired.

Color.—Upper parts dark, generally sepia or bistre, washed on sides of face and body with golden brown or ochraceous, intimately mixed with black-tipped hairs; top of head, between eyes and including ears, dusky, with an ill-defined dorsal band of the same color. Under parts dark plumbeous, faintly washed with dull pale fulvous. Hairs of feet whitish. More or less white about throat and pouches.

Cranial characters.—Skull very long and angular (pl. 7, fig. 2); frontal broad and high; top of skull in profile strongly convex; zygomatic arches broadly spreading, divergent anteriorly, and angular; brain case broad and flat; palatopterygoids narrow, their sides parallel; temporal impressions in adult males meeting in a low but well-developed sagittal ridge; interparietal deeply excavated posteriorly (trousers-shaped), reduced in advanced age by meeting of temporal ridges (fig. 6, *f* and *g*). *G. mobilensis* differs from *G. tuza* in the great breadth of the frontal interorbitally; the narrow palatopterygoids; the presence of a sagittal ridge in adult males, and the very different shape of the interpariteal (fig. 6). It differs from *floridanus* in much smaller audital bullæ, broader frontal, lower and more depressed brain case, more divergent zygomatic arches, narrower ascending branches of premaxilla and much narrower palatopterygoids. *G. mobilensis* differs from *G. breviceps*, its nearest neighbor on the west, in general form of the skull and in numerous details: in profile the top of the skull is strongly convex instead of concave; the zygomatic arches are more angular and more divergent anteriorly; the frontal is much broader interorbitally; the brain case flatter; the nasal bones broader and constricted in front of the middle; the angular process of the mandible deeply notched anteriorly.

Measurements (taken in flesh).—*Type* specimen: Total length, 260; tail vertebræ, 82; hind foot, 33.

Average of four males from type locality: Total length, 250; tail vertebræ 81; hind foot, 33.5.

Average of four females from same place: Total length, 229; tail vertebræ, 76; hind foot, 30.5.

For cranial measurements see Table C, p. 208.

Specimens examined.—Total number 23: 9 from Point Clear, Mobile Bay, Alabama, 2 from Brewton, Alabama, and 12 from Milton, Florida.

General remarks.—*Geomys mobilensis* is an inhabitant of the lowlands bordering the Gulf of Mexico east of Mobile Bay. How far its range extends to the east and north has not been ascertained. In size and coloration it seems to bear the same relation to its neighbor (*G. tuza*) of the adjacent pine barrens of Georgia that *G. breviceps* of the lowlands of Louisiana and Texas bears to its relative of the higher and drier ground further west (*G. lutescens*).

It seems a pity that such a strikingly marked animal as *mobilensis* must stand as a subspecies, but there is no reasonable doubt of its complete intergradation with *tuza* in western Georgia.

GEOMYS BURSARIUS (Shaw).

(Pl. 1; pl. 9, figs. 8 and 9; pl. 10, fig. 6; pl. 13, fig. 11; pl. 14, fig. 2; pl. 15, fig. 11; pl. 17, fig. 3; pl. 18, fig. 1; pl. 19, fig. 3; text fig. 55.)

Mus bursarius Shaw, Trans. Linnean Soc., v. 1800, 227-228, pl. 8; Genl. Zoology, Mammalia, Vol. II, pt. 1., 1801, 100-101, pl. 138.

? *Mus ludovicianus* Ord. Guthrie's Geography, 2d Am. ed., 1815, 292 (*Nomen nudum*).

Diplostoma fusca Rafinesque, Am. Monthly Magazine, Vol. II, No. I, Nov. 1817, 45.

Geomys cinerea Rafinesque, Am. Monthly Magazine, Vol. II, 1817, 45. (*Mus bursarius* renamed.)

Saccophorus bursarius Kuhl, Beiträge zur. Zool., 1820, 65.

Mus saccatus Mitchill, New York Medical Repository, Vol. VI, n. s., 1821, 249. (Type from Lake Superior, probably Minnesota.)

Pseudostoma bursarius Say, Long's Expd. to Rocky Mts., I, 1823, 406.

Ascomys canadensis Licht., Abh. Akad. Wiss. Berlin (1822), 1825, 20, fig. 2.

Geomys? bursarius Richardson, Fauna Boreali-Americana, I, 1859, 203.

Geomys canadensis LeConte, Proc. Acad. Nat. Sci., Phila., VI, 1852, 158.

Geomys oregonensis LeConte, Proc. Acad. Nat. Sci., Phila., VI, 1852, 160. (Locality erroneous.)

Type locality.—Unknown; somewhere in Upper Mississippi Valley.

Geographic distribution.—Upper Mississippi Valley from a short distance south of the Canadian boundary, in longitude 97° (Warren, Minnesota, and Grand Forks, North Dakota), southward to eastern Kansas (Neosho Falls), southeastern Missouri (Williamsville and Hunter), and southern Illinois (Belleville); east nearly to Lake Michigan (Winnebago and Fond du Lac, Wisconsin, and Cook County, Illinois); west in the Dakotas and Nebraska to the ninety-eighth or ninety-ninth meridian (Valley City and Hamlin, North Dakota; Burch, Mitchel, and Scotland, South Dakota; Niobrara, Ericson, and Kearney, Nebraska). The species belongs to the Upper Sonoran and Transition zones. See map 4, B.

General characters.—Size large; coloration dark; tail medium or rather long, scant haired, the terminal half nearly naked.

Color.—Dark liver brown or chestnut above and below, somewhat paler on the belly (belly very rarely whitish); fore feet white; hind feet soiled white; hairs of tail usually brown on basal part and white on terminal part.

Cranial characters.—Skull long, large, and angular (pl. 1); zygomata spreading, widely divergent anteriorly, angular; a well-developed sagittal crest; rostrum long and narrow for size of skull; frontal narrow and rounded interorbitally; palatopterygoids broadly lingulate, tapering posteriorly, not notched at base on outer side (pl. 14, fig. 2). The skull of *G. bursarius* does not require close comparison with any other species, though the young and females are sometimes difficult to distinguish from *lutescens*. The skull of the female differs from that of the male in much smaller size, shorter rostrum, broader interorbital region, fuller brain case, in the absence of distinct sagittal and lambdoidal crests, and in the less development of processes and ridges for muscular attachment. Skulls of *G. bursarius* differ from those of *lutescens* chiefly in greater length and angularity, the ratio of zygomatic breadth to basilar lenth of Hensel rarely exceeding 73 percent in adults; while in *lutescens* this ratio runs from 75 to 79. The brain case is higher posteriorly and the sagittal crest is much more highly developed. *G. bursarius* (in common with *lutescens*) differs from *personatus* notably in the angle of the anterior part of the zygomatic arch and in the length of the jugal. In both *bursarius* and *lutescens*, even in old age, the anterior root of the zygoma slopes back at a considerable angle; in *personatus* it stands out at nearly a right angle. In *bursarius* and *lutescens* the jugal is much longer than the basioccipital; in *personatus* it only equals the basioccipital.

Dental characters.—Face of upper incisors strongly bisulcate; small sulcus fine and close to inner edge of tooth; principal sulcus much larger and on or slightly external to median line; enamel face rounded externally and between sulci (fig. 22^2, and pl. 15, fig. 11). Molariform teeth much smaller than in the other sections of the genus; crown of last upper molar suborbicular, without heel.

Upper molariform series.—The upper premolar curves and slopes strongly forward and is concave anteriorly; the last molar curves strongly backward and is concave posteriorly. The intermediate molars curve both backward and outward; the first only slightly backward, the second strongly; both are concave externally; their roots divaricate, the first sloping forward, the second backward. (A second and greater point of divergence is between the premolar and first molar.) The premolar is nearly one-third longer than the last molar. The intermediate teeth are about as long as the premolar—sometimes longer.

Lower molariform series.—All the teeth are short compared with those of the upper series; premolar longest, largest, heaviest, and curves

strongly forward; last molar smallest, shortest, and curves strongly backward; the intermediate teeth intermediate in length. Premolar strongly concave anteriorly and nearly as concave outward; m_1 slightly concave anteriorly, strongly concave outward, and somewhat twisted on its axis; m_2 strongly concave outward and faintly anteriorly, with a slight twist; m_3 strongly concave posteriorly and moderately so outwardly.

Average measurements of 26 specimens of both sexes from eastern North Dakota (measured by J. Alden Loring): Total, 270; tail vertebræ 80; hind foot, 35. Average of 6 males from same localities: Total, 296; tail vertebræ, 90; hind foot, 37. Average of 10 females: Total, 265; tail vertebræ, 78; hind foot, 34. Average total length of 20 males and 20 females from Elk River, Minnesota, measured in flesh by Vernon Bailey: Males, 284; females, 243. In both cases many of the specimens are not full grown, hence the measurements are toc small. Unfortunately no satisfactory series of measurements is available.*

For cranial measurements see Table A, p. 204.

General remarks.—Geomys bursarius is a well-marked species, easily distinguishable by color alone from all the other bisulcate forms. It is also the largest species inhabiting the United States, although varying considerably in size in different localities. The largest form inhabits the region about Knoxville, Iowa, where the males average a foot in length.

Geomys bursarius is of much greater economic consequence than all the other species combined, for the reason that its home is in the fertile prairie region of the Mississippi Valley from central Missouri northward, covering the whole State of Iowa, nearly the whole of Illinois, and the richest and most densely populated agricultural lands of eastern Kansas, eastern Nebraska, eastern South and North Dakota, Minnesota, and southern Wisconsin.

Specimens examined.—Total number 116, from the following localities:

North Dakota: Portland, 18; Erie, 3; Casselton, 2; Buffalo, 2; Valley City, 3.

*Dr. C. E. McChesney, U. S. Army, in a paper on the Mammals of Fort Sisseton, Dakota, has recorded a valuable series of measurements of this species, all taken at that locality. While his measurements are not strictly commensurate with ours, and while many of his specimens were not full grown, his means are important, particularly as showing the average sexual difference. Reduced to millimeters his most important means are:

Mean of—	Head and body	Tail vertebræ.	Hind foot.
Thirty-three males, Fort Sisseton, South Dakota	214	79	35
Thirty-five females, Fort Sisseton, South Dakota	182	72.5	32
Sixty-eight specimens, both sexes	198	76	33

(Bull. U. S. Geol. and Geog. Survey, Terr. IV, No. 1, Feb., 1878, p. 213.)

South Dakota: Flandreau, 1; Fort Sisseton, 1; Travare, 2; Scotland, 1.

Minnesota: Ortonville, 2; Browns Valley, 1; Elk River, 39.

Iowa: Council Bluffs, 1; Knoxville, 16.

Nebraska: Niobrara, 3; Verdigris, 1; Columbus, 1; Ames, 1; Blair, 1; Norfolk, 2.

Kansas: Onaga, 3.

Missouri: Hunter, Carter County, 4; Williamsville, Wayne County, 8.

EARLY HISTORY OF GEOMYS BURSARIUS.

The early history of this gopher is somewhat obscure. It was originally described by Shaw in the year 1800 and was named *Mus bursarius.** The description is very brief and is as follows: "Ash-coloured rat, with short round nearly naked tail, pouched cheeks, and the claws of the forefeet very large, formed for burrowing in the ground." Shaw states further: "This quadruped was taken by some Indian hunters in the upper parts of interior Canada, and sent down to Quebec. It is now in the possession of Governor Prescot." The description is accompanied by a full-size engraving of the animal, with cheek pouches turned inside out and distended. The skin evidently was greatly overstuffed. No grooves are shown on the upper incisors.

The next year (1801) Shaw redescribed the same specimen as follows: "It is about the size of a brown or Norway rat, and is of a pale greyish-brown colour, rather lighter beneath; the length to the tail is about 9 inches, and that of the tail, which is but slightly covered with hair, about 2 inches: the legs are short; the fore feet strong, and well adapted for burrowing in the ground, having five claws, of which the three middle ones are very large and long; the interior much smaller, and the exterior very small, with a large tubercle or elbow beneath it. The claws on the hind feet are comparatively very small, but the two middle are larger than the rest, and the interior one is scarce visible: the teeth are extremely strong, particularly the lower pair, which are much longer than the upper: the ears are very small." (General Zoology, vol. II, part 1, Mammalia, 1801, pp. 100–101.) He gave a new engraving of the animal, stating that in the figure previously published (in the Transactions of the Linnean Society) "the claws on the fore feet are represented as only three in number, and are somewhat too long, weak, and curved. The engraving in the present plate is a more faithful representation, and is accompanied by an outline of the head, in its natural size, as viewed in front, in order to shew the teeth and cheek-pouches." This plate contains three figures: a side view, as in the earlier engraving; a front view, reduced, and a natural-size front view in outline. The cheek pouches are everted, as before, protruding from

*Transactions of the Linnean Society, London, vol. V, 1800, pp. 227–228; description read before the society June 4, 1799.

the sides of the face as great bursæ. Although the teeth are distinctly shown in these engravings, no trace of a groove is apparent, unless an incomplete dotted line near the middle of each upper incisor in the outline figure was intended to indicate it. The size of the incisors in this figure agrees exactly with the size of these teeth in specimens of *Thomomys talpoides* from Manitoba, and the size and shape of the fore feet and claws are as in *Thomomys*, thus differing widely from the same parts in *Geomys*, in which the teeth and claws are very much larger and heavier.

The color of the body (which he describes as "pale greyish-brown, rather lighter beneath"), the size and shape of the forefeet and claws, the size of the incisors, the absence of the deep median furrow so conspicuous in *Geomys* (which could hardly have been overlooked both in the description and figure), together with the statement that the animal came from the interior of Canada, all indicate that the species now known as *Thomomys talpoides* was the animal Shaw had before him.

The only point mentioned by Shaw in either of his descriptions of the type specimen of '*Mus bursarius*' that does not apply strictly to *Thomomys*, to the exclusion of *Geomys*, is the length of the animal, which he gives as 9 inches. This is easily explained on turning to the figure, which shows the specimen to be greatly overstuffed—a common error in taxidermy resulting from the exceedingly loose and distensible skins of these animals, which are nearly always stretched in taking off from the body.

Recapitulating, Shaw's description and figures seem to establish the following points:

(1) The type specimen of *Mus bursarius* came from the "upper parts of interior Canada," the home of *Thomomys*. No member of the genus *Geomys* reaches Canada, its northernmost known point being Warren, Minnesota.

(2) The type specimen of *Mus bursarius* was "ash coloured" or "pale greyish-brown, rather lighter beneath," exactly as in *Thomomys*. The color of the only species of *Geomys* inhabiting the Upper Mississippi Valley is dark chestnut or liver-brown, both above and below.

(3) The detailed description given by Shaw in his General Zoology makes no mention of grooves in the incisors, though these teeth are described with particularity. In *Geomys* the upper incisors are deeply furrowed; in *Thomomys* they are plane.

(4) Not one of the four figures of the type specimen of *Mus bursarius* published by Shaw shows any trace of the grooved incisors of *Geomys*, and two of these figures are front views, one natural size.

(5) The size of the teeth, fore feet, and claws in Shaw's natural-size figure agree with these parts in Manitoba specimens of *Thomomys* and are very much smaller than in *Geomys*.

From the above facts it would appear that the animal described by Shaw under the name *Mus bursarius* is the gray pocket gopher of Man-

itoba and the Dakotas (*Thomomys talpoides* of recent authors) and not the red pocket gopher of the Mississippi Valley (*Geomys bursarius* of recent authors). This view would necessitate a slight change in nomenclature: *Thomomys talpoides* Auct. would become *Thomomys bursarius* (Shaw), and *Geomys bursarius* Auct. would become either *Geomys fuscus* (Rafinesque) 1817, or *Geomys saccatus* (Mitchill) 1821.* Fortunately no change in the generic name would be required, since Rafinesque based his genus *Geomys* on *G. pinetis* [= *G. tuza*] of the pine barrens of Georgia.

Clear as the case seems to have been left by Shaw, it became shrouded in obscurity by the writings of subsequent authors.

In 1820 Heinrich Kuhl published his Beiträge zur Zoologie, in which he described the genus *Saccophorus*, basing it on the *Mus bursarius* of Shaw. He states that the specimen examined by him was formerly in Bullock's Museum, but then in Paris ("in Museo Bullokiano, nunc Parisiensi," p. 65), but does not intimate that it was Shaw's specimen. In the diagnosis of the genus he states that the upper incisors have two sulci, of which the external is broader and deeper, thus describing the condition in typical *Geomys*.

Lichtenstein, in a paper written in 1822, but not published until 1825, says: "When I was in London in the summer of 1819 I saw in the Bullock collection the specimen described by Shaw" (Überäussere Backentaschen an Nagethieren, Abh. K. Akad. Wiss. Berlin [for 1822], 1825, 14–15). He then goes on to describe another specimen, assumed to belong to the same species, which he says he had recently received from North America.

The first positive statement I have been able to find to the effect that Shaw's specimen had grooved incisors was made by Richardson more than a quarter of a century after the publication of Shaw's last description. Richardson states that the engraving of Shaw's *Mus bursarius* published in the Linnean Transactions was drawn by Maj. Davies,† and that "the specimen figured by Major Davies, in the Linnean Transactions, was of a pale gray colour, and 9½ inches long from the nose to the root of the tail, which measured 2½ inches. The belly was paler than the back, and the cheek-pouches were covered with very short pale hairs. Its superior incisors were deeply grooved in the middle, and more faintly close to their inner margins" (*Ibid.*, 203). As to the final disposition of this specimen he says: "The identical specimen

** Diplostoma fusca* Rafinesque, Am. Monthly Mag. II, 1817, 45, is little more than a *nomen nudum*, the only specific description being "entirely brown, length 12 inches." But the generic diagnosis, though full of errors, leaves no doubt as to the animal; and the locality assigned, "Missouri Territory," is sufficiently exact in connection with the size and color of the species. If, however, this name is not considered available, the next in point of date seems to be *Mus saccatus* Mitchill, Medical Repository, vol. VI, 1821, 248–250; type "from the region bordering on Lake Superior," doubtless Minnesota, where the animal is abundant. The bisulcate upper incisors are described in detail by Mitchill.

† Fauna Boreali-Americana, 1829, 199.

described by Shaw, * * * on the dispersion of Mr. Bullock's collection, passed into the hands of M. Temminck" (*Ibid.*, p. 199).

That this particular specimen is now in the Leiden Museum is certain, for it is mentioned by Dr. F. A. Jentink, the able director of the Rijks Museum, in his *Catalogue Systématique des Mammifères*, XII, 1888, p. 93. In response to a letter of inquiry, Dr. Jentink has had the kindness to write me as follows: "On the underside of the stand [of the specimen above mentioned] I see the following words written with pencil: 'Mus bursarius, Cabinet Bullock, Londres.' So you may be sure of the fact that this specimen truly has been bought from Bullock's auction. As to the animal itself and its identity with Shaw's description, you may judge if I tell you that it has the cheek pouches turned inside out and distended, but not in the extraordinary way as represented in Shaw's figure 138, vol. II, p. 1. The incisors are deeply grooved. Shaw's figure represents, without doubt, an overstuffed specimen; meanwhile our specimen seems to be in excellent proportions and very well-preserved condition. Length of the animal, 9.8 inches, measured from the upper lip along the dorsal line of the body; tail about 2.8 inches. The color of our specimen is a desert color, more reddish toward head and hinder parts of the body."

In 1857 Baird made the following statement, evidently based partly on the remarks of Richardson, already quoted, and partly on an erroneous translation of the statements of Kuhl and Lichtenstein. Baird says: "The same skin referred to by Shaw was subsequently investigated by Kuhl, and then by Lichtenstein. It was for a time in the celebrated museum of Mr. Bullock, of London, and is said to have been purchased by Temminck at the sale of this collection, and is doubtless now in the Leyden Museum." (Mammals of North America, 1857, 376.) But Kuhl does not say that his specimen was the same as Shaw's, and Lichtenstein distinctly states that the animal described by him was not Shaw's specimen (which he says he saw in London in 1819), but one that he "received a short time ago with other North American mammals."

If it is true that the specimen described by Kuhl is really the same as that described by Shaw twenty years earlier, and afterwards mentioned by Lichtenstein as having been seen by him in London in 1819, it would be certain that no other animal than the furrowed-toothed pocket gopher of the Upper Mississippi Valley (*Geomys*) could be meant. But unfortunately Kuhl says nothing on this point, and it must be admitted that the conspicuous discrepancies between his description and Shaw's are hard to reconcile on the assumption that they refer to the same specimen. Shaw says the body of his animal as stuffed measured 9 inches, and the tail 2 inches. Kuhl says the body measured 7½ inches, and tail 2⅓ inches. Shaw described his animal as "ash-coloured," and "pale greyish-brown," while Kuhl says that his inclined to rufous ("rufescens")—the proper color for *Geomys*.

Is it not possible that Richardson, in translating the Latin of Kuhl or the German of Lichtenstein, fell into the same error as Baird? At all events it should not be forgotten that Richardson wrote nearly thirty years later than Shaw—an interval sufficiently long to allow additional specimens to reach England and also to favor slips of memory. It should be further remembered not only that Lichtenstein had a specimen additional to that described by Shaw, but also (and much more important) that there appears to be no ground for the assumption that Kuhl's description was taken from Shaw's specimen; in fact the marked discrepancies between them seem to prove the contrary, as pointed out above.

Shaw's and Richardson's descriptions are utterly irreconcilable on the assumption that they refer to the same specimen, but would be perfectly intelligible if it can be shown that a second specimen found its way into the Bullock collection between the years 1800 and 1819.

The matter is still further complicated by Richardson himself, who, writing in 1831, says: "We lately received several specimens of the *Mus bursarius* of Shaw (which is a true *Geomys*, with pouches opening internally) from the banks of the Saskatchewan." (Zoology of Beechey's Voyage of the Blossom, 1839, 9.) This statement shows that Richardson's ideas respecting the status and distribution of the several members of the group were badly confused, for it is now well known (as before stated) that no species of *Geomys* reaches the plains of the Saskatchewan; indeed the genus has not been found to enter Canada at all. The use of the generic name *Geomys* by Richardson, however, has no significance, since he applied the name to *Thomomys* as well as *Geomys*, and it is certain that his Saskatchewan animal is *Thomomys talpoides* Auct. His identification of the species with *Mus bursarius* of Shaw would be in accord with my belief that Shaw's animal could have been no other than the common *Thomomys* of Manitoba and the northern plains generally, except for his previous statement, already quoted from Fauna Boreali-Americana, that the Bullock specimen had grooved incisors and was the identical specimen described by Shaw. These conflicting statements by the same author I am utterly unable to reconcile.

GEOMYS LUTESCENS Merriam.

(Pl. 9, figs. 5 and 7; pl. 14, fig. 14.)

Geomys bursarius lutescens Merriam, N. Am. Fauna, No. 4, Oct. 8, 1890, 51.

Type locality.—Sand hills on BIRDWOOD CREEK, LINCOLN COUNTY, WESTERN NEBRASKA. (Type in U. S. National Museum.)

Geographic distribution.—The Upper Sonoran belt of the Great Plains from southwestern South Dakota southward to Colorado, Texas, covering the sand-hill region of western Nebraska, extreme eastern Wyoming (between the North Platte and Cheyenne rivers) western Kansas,

eastern Colorado, western Oklahoma, and western Texas, ranging east to or a little beyond the ninety-ninth meridian (map 4, C).

General characters.—Size medium or rather large; coloration pale; tail moderate; scant haired; skull short.

Color.—Upper parts in winter drab, liberally mixed with black-tipped hairs along the median line, forming a distinct dorsal band from end of nose to rump; in summer pale buffy-ochraceous or very pale dull fulvous without dorsal band. Under parts buffy, usually white in the young and sometimes white in adults. Along the eastern and southern limits of its range the upper parts are decidedly more fulvous than in the typical animal.

Cranial characters.—Skull intermediate in size between *breviceps* and *bursarius;* zygomata broadly and squarely spreading, strongly divergent anteriorly; nasals normally elongate wedge-shaped, as in *bursarius*, but sometimes broadening in posterior third; temporal impressions normally uniting, at least posteriorly, in a low sagittal ridge (pl. 9, fig. 7), but sometimes remaining apart, separated by an interspace 1 to 3 mm. broad (pl. 9, fig. 5) [this form is commonest in the southwestern part of the range of the species]; interparietal varying from subquadrate in the young to subtriangular in adults, its size decreasing with age and the posterior suture becoming obliterated by ankylosis with the supraoccipital; palatopterygoids usually lingulate and tapering posteriorly as in *bursarius*, but somewhat narrower and sometimes strap-shaped.

Skulls of *Geomys lutescens* differ from those of *G. bursarius* chiefly in smaller size, greater relative breadth and flatness (the brain case as well as the rostrum being considerably shorter than in true *bursarius* from the Mississippi Valley), and in lacking the high sagittal crest of *bursarius*. Old skulls of *lutescens* have strongly spreading zygomatic arches which are very much broader anteriorly than posteriorly, and as a rule the premaxilla extends a little further back than in *bursarius*.

Skulls of *lutescens* bear a strong resemblance to those of *breviceps*, from which they differ in having the frontal region less depressed; the zygomatic arches more squarely spreading and more decidedly angular anteriorly; the nasal bones broader posteriorly; the ascending branches of the premaxilla longer and less blountly rounded posteriorly; the temporal impressions normally meeting posteriorly in a low sagittal ridge instead of remaining distant; the occiput more truncate (less bulging) posteriorly; the rostrum normally broader.

The cranial characters that distinguish *lutescens* from *texensis*, *arenarius*, and *personatus* are mentioned under the heads of these species.

Measurements.—Average of 28 specimens of both sexes from western Nebraska: Total length, 256; tail vertebræ, 77; hind foot, 32. Average of 12 males: Total length, 270.5; tail vertebræ, 84; hind foot, 33.5. Average of 10 females: Total length, 246; tail vertebræ, 72; hind foot, 31.5.

For cranial measurements, see Table A, p. 204.

Specimens examined.—Total number of typical or nearly typical specimens 118, from the following localities:

South Dakota: Pine Ridge Agency, 2; Rosebud Agency, 3.

Nebraska: Chadron, 1; Kennedy, 13; Valentine, 3; Ewing, 2; Oakdale, 2; Crawford, 1; Snake River, Cherry County, 1; Clarks Canyon, Cherry County, 7; Dismal River, Thomas County, 1; Niobrara River, Sheridan County, 1; near North Platte, Lincoln County, 4; Birdwood Creek, 1; Myrtle, 3; Sidney, 1; Calloway. 4· Kearney, 1.

Wyoming: Lusk, 3; Uva, 1.

Colorado: Las Animas, 6; Denver, 1; Pueblo, 4; Limon, 3; Burlington, 1; Chivington, 6.

Kansas: Trego County, 3.

Oklahoma: Woodward, 3.

Texas: Canadian, 5; Tascosa, 4; Newlin, 3; Childress, 12; Vernon, 9; Colorado, 3.

Number of non-typical specimens 18, from the following localities:

Kansas: Garden Plain, 4; Belle Plain, 5; Cairo, 6; Kiowa, 2; Ellis, 1.

General remarks.—*Geomys lutescens* is a pallid species inhabiting the arid plains west of the ninety-ninth meridian. Its characters are very constant throughout most of its range, and if it intergrades with *bursarius* it must do so in the narrow strip between the ninety-eighth and ninety-ninth meridians. In southeastern Kansas an aberrant form exists that seems to be an intergrade between the three types, *bursarius*, *lutescens* and *breviceps*, but a larger series of specimens than at present available is needed to prove it. This animal is smaller than *lutescens*, nearly as dark above as *bursarius*, and paler below than either. Some specimens indeed have the belly pure white, as in *texensis*. Specimens of this apparently intermediate form (mostly immature) have been examined from Cairo, Kiowa, Garden Plain, and Belle Plain, Kansas.

Mr. Vernon Bailey states that in western Nebraska, where typical *lutescens* is abundant, the light sandy soil is probably improved by their diggings, but that they do considerable damage in grain fields and to young trees on the tree claims.

GEOMYS BREVICEPS Baird.

(Pl. 9, fig. 6.)

Geomys breviceps Baird, Proc. Acad. Nat. Sci. Phila., VII, April, 1855, 335.

Type locality.—PRAIRIE MER ROUGE, MOREHOUSE PARISH, LOUISIANA.

Geographic distribution.—The alluvial lowlands of the Mississippi Valley and Gulf coast in southern Arkansas, Louisiana, and Texas, and the valley of the Arkansas River; north nearly to southern Kansas, and west to near the ninety-eighth meridian, where it is replaced by *G. lutescens*. It is therefore a member of the Austroriparian fauna (map 4 D).

General characters.—Size small; color very dark both above and below; tail of medium length, its distal half nearly naked.

Color.—Upper parts dark russet-brown, darkest along the middle of the back (but no trace of dorsal band in Louisiana specimens); nose and front of face to above eyes dusky, more or less tinged with russet; sides washed with pale fulvous; belly dark plumbeous, more or less obscured by pale buffy-fulvous tips to the hairs; feet and throat white; hairs on base of tail dusky (remainder of tail practically naked). The color of the back is hard to describe, and the term used ('russet-brown') is intended only as roughly indicating the general effect. The individual hairs are dark plumbeous, with a narrow subapical zone of dark fulvous, tipped with sooty.

Cranial characters.—Skull similar to *G. lutescens* in general appearance but smaller; zygomata broadly spreading; frontal flat, depressed; nasals narrow, emarginate posteriorly, their sides nearly parallel for posterior two-thirds, abruptly divergent anteriorly; ascending branches of premaxilla broad and bluntly rounded posteriorly; interparietal small, very irregular, and much cut up with tortuous windings of the sutures as in true 'Wormian' bones; temporal impressions never uniting in a sagittal crest but permanently distant, the interspace elevated, forming a broad convex band (3 to 5 mm. in width) along the top of the skull posteriorly; jugal longer than basioccipital, bluntly rounded anteriorly; occiput bulging behind lambdoid suture, but not so far as in *texensis*; pterygoids narrow, tapering posteriorly.

Skulls of *breviceps* may be distinguished from those of *lutescens* by the following characters (pl. 9, fig. 6): Size smaller; nasals narrower, shorter, and strongly emarginate posteriorly; ascending branches of premaxilla normally shorter and more bluntly rounded posteriorly; temporal impressions persistent, distant, the bone thickened between them; interparietal 'Wormian'-like; zygomata more rounded; interorbital region more depressed. Nevertheless, the cranial resemblances are striking in view of the dissimilarity of the animals in size and external appearance. Moreover, skulls of *breviceps* from the western part of its range have broader nasals; and skulls of *lutescens* from adjacent territory have a narrow sagittal area (resulting from permanently distant temporal impressions). It is probable, therefore, that the two forms will be found to intergrade.

Skulls of *breviceps* differ from those of *texensis* in larger size, much more spreading zygomata; longer and very much narrower nasals; broader, flatter, and more depressed frontal interorbitally; much longer jugal; smaller and more irregular interparietal; less bulging occiput; broader and more bluntly rounded ends to ascending branches of premaxilla. Viewed in profile, the skull of *breviceps* is flat and somewhat depressed or concave between the orbits; that of *texensis* is normally convex.

Average measurements of 40 specimens of both sexes from type locality (Mer Rouge, Louisiana): Total length, 219; tail vertebræ, 64; hind foot, 27. Average of 15 males from same place: Total length, 231; tail

vertebræ, 70; hind foot, 28. Average of 23 females from same place: Total length 212; tail vertebræ, 61; hind foot, 26.5.

For cranial measurements see Table A, p. 205.

General remarks.—The type form of *Geomys breviceps* inhabits northern Louisiana, east of the Red River, the exact type locality being Prairie Mer Rouge in Morehouse Parish, near the northern boundary of the State and only a short distance west of the Mississippi River. The species as a whole is an inhabitant of the dark alluvial soils of the lowlands bordering the Lower Mississippi and its tributaries and the Gulf coast of Texas, whence it spreads westward nearly or quite to the ninety-eighth meridian. To the southward it reaches Nueces Bay. On the west it probably intergrades with *texensis* and *lutescens*. On the north there seems to be a hiatus between its range and that of *bursarius*; but if pocket gophers are ever found in northern Arkansas, southwestern Missouri, southeastern Kansas, or northeastern Indian Territory, they are likely to prove intergrades.

Departures from the type.—Specimens from extreme points in the range of the species differ much from the type. Two of these forms are here named as subspecies (*G. breviceps sagittalis* and *G. breviceps attwateri*). Others are regarded as slightly aberrant forms not meriting recognition by name; others still as intergrades. The following, contained in the Department of Agriculture collection, seem worthy of mention:

(1) A large dark form inhabiting the valley of the Arkansas River. The skulls point toward intergradation with the interior animal. Specimens from Tulsa and Fort Gibson, Indian Territory, and Fort Smith, Arkansas, resemble *breviceps* in coloration, while those from Ponca Agency, Indian Territory, are redder, shading strongly toward *lutescens*.

(2) A form from the valley of the Red River of the South, along the boundary between Texas and Indian Territory (specimens from Gainesville, Tex., and from Indian Territory opposite Arthur, Tex.). A small reddish form resembling *breviceps* externally, but with dark belly and a short tail. The skulls are more like *texensis* in general form (full brain case and narrow zygomata), and in the shortness and breadth of the nasals; but the ascending arms of the premaxilla are even shorter and more bluntly rounded posteriorly than in *breviceps*. The frontal and interparietal are intermediate between the two.* Regarded as an intergrade.

(3) A form from Shreveport, Louisiana. Much redder than true *breviceps*, resembling *texensis* in coloration of upper parts, but with dark belly. The skull differs from typical *breviceps* in more angular zygomata, broader nasals, and less depressed frontal. Regarded as a slight local departure from *breviceps*.

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* Skull No. 47590 ♂ ad. from Gainesville, Texas, is an excellent example of this form.

(4) A form from Galveston Bay, Texas (specimens from Clear Creek and Arcadia). A small, dark, highly-colored form with the head nearly black, and the throat and fore feet usually wholly or partly white, in sharp contrast with the dark of the surrounding parts. The skull differs from that of typical *breviceps* in smaller size, and in having shorter and broader nasals. Regarded as a subspecies and described under the name *sagittalis*. (Pl. 9, fig. 4.)

(5) A form from the coastal plane of Texas (specimens from Brenham, Milano, Hearne, Marquez, and Palestine.) Usually has a well-marked dark dorsal band, and the skulls differ from typical *breviceps* in having shorter and broader nasals. Skulls of old males from these localities are unusually short and have broadly spreading zygomata. The nasals are very broad posteriorly in comparison with true *breviceps*. Regarded as an aberrant form, perhaps shading toward *texensis* on one side and toward *attwateri* and *sagittalis* on the other.

(6) A form from the extreme southern limit of the range of the species on and near the Gulf coast of Texas. (Specimens from Rockport, Aransas County; Tallys Island, Aransas County, and near San Antonio.) A large dark form with a dark dorsal band in some pelages, and peculiar cranial characters: angular and strongly divergent zygomata, very broad ascending arms of premaxilla, and so on. Regarded as a subspecies, and described under the name *attwateri* (pl. 9, fig. 3).

Specimens examined.—Total number, 274, from the following localities:

Typical or nearly typical.—Mer Rouge, Morehouse Parish, Louisiana (type locality), 42; Pineville, Rapides Parish, Louisiana, 2; Provencal, Natchitoches Parish, Louisiana, 4; Shreveport, Caddo Parish, Louisiana, 8; Camden, Ouachita County, Arkansas, 1; Benton, Arkansas, 7; Fort Smith, Arkansas, 7; Fort Gibson, Indian Territory, 16; Tulsa, Indian Territory, 2.

Not typical.—Gainesville, Cook County, Texas, 5; Decatur, Texas, 1; Indian Territory, near mouth of Boggy River (opposite Arthur, Texas), 4; Ponca Agency, Oklahoma, 6; Oklahoma City, Oklahoma, 3. The following, all from Texas: Longview, 4; Mineola, 14; Terrell, 7; Troup, 1; Palestine, 5; Marquez, 5; Hearne, 9; Milano, 12; Brenham, 7; Victoria, 1; Inez, 3; Navidad River, 1; Houston, 9; Matagorda Bay, 9.

Subspecies sagittalis.—Mouth of Clear Creek, Galveston Bay, 4; Arcadia, Galveston Bay, 22.

Subspecies attwateri.—Rockport, Aransas County, 40; Tallys Island, Aransas County, 3; Calaveras, Wilson County, 3; San Antonio (18 miles south), Bexar County, 7.

Mr. Vernon Bailey, chief field naturalist of the Division, visited the type locality of *Geomys breviceps*, Prairie Mer Rouge, Morehouse Parish, Louisiana, in June, 1892, for the purpose of obtaining a series of duplicate types of the species. He found it common throughout the fields of the open country and along roads and fields in the woods of the flat land,

except where flooded, but not in standing timber or on hilly land. He states: "They do not seem to be so common in cultivated land as in pastures and along fences and roadways. In one pasture of 20 acres we caught fifteen and one remained. They were more abundant at this point than elsewhere—probably twice as numerous to the area as they would average over the whole prairie. The damage done in the pasture by covering grass was trifling. This species does not seem to dig extensively, and the hills are small. Usually one or two are thrown up in a night. In one place, where a gopher had run his tunnel in a straight course, I counted sixteen hills in a line 6 rods long (measured). A hill of average size measured 24 by 15 inches in diameter and 5 inches in height. Probably the reason the gophers do not dig more extensively is that food is abundant and the soil compact. The greatest damage the farmers claim from gophers, or 'salamanders' as they are called here, is that they carry the tubers of the troublesome cocoa or nut grass from place to place, often bringing them from a roadside or waste place and storing a large quantity in their burrows in gardens or fields and leaving them to grow where they had been kept out with great difficulty. This cocoa grass is one of the worst plants with which the farmers are troubled and is very difficult to get rid of when once started in the land. Small tubers are borne along the roots, and these are carried by the gophers, though I have not found them in their pockets. The stomachs examined contained green vegetable matter. White clover seems to be a favorite food. Most of the specimens taken were moderately fat. In June the young were half grown to nearly full grown. Of 27 specimens which I examined, 12 were males and 15 females."*

Mr. C. L. Newman writes me that at Camden, Arkansas, this species (specimen received for identification) is abundant in sections of the Ouachita River Valley, where they are known almost exclusively as 'salamanders.' He says: "They seem to prefer old fields that have grown up in pine. I know of a place about a mile from Camden where the surface of about an acre of ground is mulched with loose earth brought from their burrows. Last year (1893) I caught twenty-three from about 6 acres of ground."

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* Mr. Vernon Bailey contributes the following notes on a specimen examined in the flesh at Mer Rouge, La., in June, 1892: "Size small; pelage very soft and silky; skin loose, as though much too large for the body; body soft and flabby; soles of feet, nose, and end of tail hairless, smooth, shining, and white when clean. Lips hairy over the edges, but roof of mouth not hairy all the way across, a narrow line of smooth skin extending along the median line to the incisors; eyes small for a *Geomys;* cornea relatively large, measuring 3 mm. across, nearly equaling diameter of ball; no apparent lid, eye opening 3.5 mm. by 2 mm. (normally), its long axis parallel to a line drawn from ear to tip of nose; color of eye appearing shiny black; ears consist of a circular rim 1 mm. high and about 5 mm. in diameter; opening of meatus 2 by 2.5 mm., slightly elongated vertically; mustache spreading forward and back; distance from eye to end of nose 21 mm.; from eye to center of ear, 17 mm."

GEOMYS BREVICEPS SAGITTALIS subsp. nov.

(Pl. 9, fig. 4.)

Type from CLEAR CREEK, GALVESTON BAY, TEXAS. No. $\frac{32936}{44957}$ ♂ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected March 28, 1892, by William Lloyd. (Original number 1181.)

Geographic distribution.—Gulf coast of Texas about Galveston Bay.

General characters.—Similar to *breviceps*, but smaller and more highly colored; head very dark; throat and fore feet pure white in sharp contrast to dark of surrounding parts. The skull differs in having a distinct sagittal crest and in other particulars.

Color.—Upper parts rich, glossy, russet brown, strongly tinged with fulvous, becoming dusky along the middle of the back and head (but no distinct dorsal band); entire head and nose very dark, almost black, but washed in places with fulvous; inside of cheek pouches, chin, throat (breast also in some specimens), and fore legs pure white in sharp contrast. On the upper side of the fore legs the dark color of the sides reaches down about half way to the wrists and ends abruptly with a sharp line of demarkation. The under side of the fore legs is pure white to elbow. The belly varies from whitish, strongly washed with buffy ochraceous, to fulvous. The Arcadia specimens are not exactly like those from the mouth of Clear Creek.

Cranial characters (type specimen).—Skull similar to that of *breviceps* but smaller; zygomata more divergent anteriorly (in male); nasals shorter and broader posteriorly, bringing the constriction much nearer the middle; audital bullæ smaller; ascending branches of premaxilla narrower posteriorly; temporal impressions meeting in a well marked sagittal crest in male. In the female the temporal impressions never meet in a sagittal crest; the brain case is smoothly rounded, and the interparietal persists as a relatively large bone.

In the Arcadia males the temporal impressions do not meet in a sagittal crest as in the type.

Measurements (taken in flesh).—*Type:* Total length, 225; tail vertebræ, 70; hind foot, 27.

Average (of 5 males from Arcadia, Galveston County): Total length, 220; tail vertebræ, 64; hind foot, 26.

Average (of 15 females from same place): Total length, 196; tail vertebræ, 54; hind foot, 23.

For cranial measurements, see Table A, p. 205.

Specimens examined.—Total number 24: 4 from Clear Creek, Galveston Bay, and 20 from Arcadia, Galveston County, Texas.

General remarks.—To the northwestward *sagittallis* passes into the coastal plain form already mentioned under the head of *G. breviceps*. Old males of this form sometimes develop remarkably broad skulls. The broadest skull that I have seen in the restricted genus *Geomys* is an old male from Brenham, Washington County, Texas (No. 63612). It affords the following measurements and ratios: Basal length, 40;

basilar length of Hensel, 37; zygomatic breadth, 28.5. Ratio of zygomatic breadth to basal length, 71; to basilar length of Hensel, 77.

GEOMYS BREVICEPS ATTWATERI * subsp. nov.

(Pl. 9, fig. 3.)

Type from ROCKPORT, ARANSAS COUNTY, TEXAS. No. 51382 ♂ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected November 18, 1892, by H. H. Keays. (Original No. 36.)

Geographic distribution.—Coastal plain and islands of Texas between Matagorda and Nueces bays; penetrates the interior to within a few miles of San Antonio. The south side of Nueces Bay is the home of another form (*G. personatus fallax*).

General characters.—Similar to *G. breviceps*, but larger and less dark in color; feet and basal third to half of tail moderately well haired for a *Geomys;* terminal half to two-thirds of tail nearly naked; zygomatic arches angular, strongly divergent anteriorly.

Color.—Upper parts russet brown, becoming dusky on the head and usually along the median part of the back; under parts varying from soiled whitish to buffy ochraceous. In some specimens the color of the upper parts is less fulvous than in others, and the dark dorsal band is variable; in some specimens it is absent, sometimes the head is nearly black from end of nose to occiput, the blackish area limited laterally by the eyes and ears, the sides of the face being russet in rather strong contrast. The type specimen is in this pelage, except on the hinder part of the back and rump where the more fulvous summer pelage remains, without trace of the dorsal band.

Cranial characters.—Skull similar to that of *breviceps*, but frontal less depressed interorbitally; zygomata less spreading, strongly divergent anteriorly, more angular, more depressed, the maxillary arm sloping strongly backward; ascending branches of premaxilla broader and usually more abruptly truncate posteriorly; nasals shorter and normally convex instead of emarginate posteriorly. The nasals are normally so narrow posteriorly, and the premaxillæ so broad, that in some cases the latter nearly meet behind the former (as in the type specimen, pl. 9, fig. 3). Normal skulls of *attwateri* differ markedly from those of *fallax* in the form of the zygomata, the maxillary arms sloping strongly backward instead of standing out at right angle, and the outer sides being strongly divergent instead of nearly parallel. The nasals are narrower and contracted posteriorly, the ascending arms of the premaxilla broader, and the audital bullæ less swollen. In the series of fifty-two skulls of *Geomys breviceps attwateri* now before me, three depart from the normal in general outline, as seen from above, and resemble *fallax* in the form of the anterior part of the zygomatic arches, which stand out squarely from the cranial axis and have the antero-external angles

* Named in honor of Mr. H. P. Attwater, of San Antonio, Texas, who collected nearly all of the specimens.

broadly rounded. In other respects they are typical *attwateri*. All are very old males, collected at Rockport by Mr. Attwater (original Nos. 102, 118 and 119). They now belong to the American Museum of Natural History in New York.

Measurements (taken in flesh).—*Type:* Total length, 250; tail vertebræ, 85; hind foot, 30.5.

Average of 10 males from type locality: Total length, 255; tail vertebræ, 80; hind foot, 30.

Average of 7 females from type locality: Total length, 220; tail vertebræ, 68; hind foot, 28.

For cranial measurements see Table A, p. 205.

Specimens examined.—Total number 53, from the following localities on or near the Gulf coast of Texas: Rockport, Aransas County (type locality), 40; Tallys Island, Aransas County, 3; Calaveras, Wilson County, 3; San Antonio (18 miles south), Bexar County, 7.

General remarks.—*Geomys breviceps attwateri* is a medium-sized species closely resembling its near neighbor *G. fallax* in color, though somewhat darker, and with the hind foot shorter. The resemblance to *G. breviceps* is much closer in the plumbeous russet pelage than in the fulvous pelage.

Mr. H. P. Attwater has kindly contributed the following memorandum respecting the habits of this gopher at Rockport, Texas: "As soon as the warm weather sets in, from about May to September, very few gophers are observed working. The soil is sandy, and at all times damp, dampness known as 'natural subirrigation.' In the hot weather the dampness does not come as near the surface as in the cooler months. I have thought that perhaps the gophers travel deeper in summer, but now think the chief reason why they do not throw up hills in summer, as they do in fall and winter, is that during the summer months the soil is so full of roots, suckers, bulbs, etc., that they do not have far to go before finding all they can eat, and that the reason they work so much after the summer months are over is because they are hunting around to find some bulb or root which was their favorite food in summer, and which they commenced to find about the month of May, and was over with in September. The animals are very abundant all over the peninsulas in Aransas County, wherever the soil is sandy. There is hardly a foot of land that has not been 'plowed' several times over by gophers, and I believe the fertility of some sections has been greatly improved by them, by bringing the poorer soil up to the top. I have noticed that the richer the land the richer the gophers. Of course they do considerable damage to vegetable crops, especially to young fruit trees and cuttings just rooting. The samples sent you of mulberry trees cut by gophers were from the Faulkners' ranch, on St. Charles peninsula, in the eastern part of the county. Mr. Samuel Walker, the manager of the ranch, told me that he killed over two hundred and fifty gophers in his young pear orchard between the 1st of

March and April 15, 1893. This orchard was set out where sweet potatoes had grown the year before, and they came up again and covered the ground, and I think the potatoes attracted the gophers in the first place more than the pear trees."

GEOMYS TEXENSIS sp. nov.

(Pl. 9, fig. 2; pl. 13, fig. 12.)

Type from MASON, MASON COUNTY, TEXAS. No. $\frac{1690}{2259}$ ♀ ad. Merriam collection. Collected by Rev. Ira B. Henry, December 17, 1885.

Geographic distribution.—Mason County, central Texas, and probably thence southerly to the Rio Grande; limits of range unknown (map 4, E).

General characters.—One of the smallest known species; tail short; terminal third nearly naked.

Color.—Upper parts liver-brown, finely mixed with black-tipped hairs, much as in *G. bursarius.* Under parts and feet white. The hairs of the belly are plumbeous at base in the type and other winter specimens; in summer specimens they are white throughout. Throat suffused with pale buffy fulvous, forming a complete collar. In some specimens this collar is interrupted along the median line. The color of the upper parts is darker in winter than in summer, as usual in the genus. There is no trace of a dark dorsal band in adults, but in the young the black-tipped hairs are sometimes concentrated along the middle of the back, forming an ill defined dark streak.

Cranial characters.—Skull small (smallest of the known species), smooth; zygomata only moderately spreading and normally but slightly divergent anteriorly; nasals short, rather broad and convex or truncate behind; ascending branches of premaxilla long, normally passing plane of lacrymals, usually straight on inner edge behind nasals and attenuate on outer edge; temporal impressions not forming distinct ridges and not uniting in a sagittal crest, usually separated by interspace 1–3 mm. broad in adults; jugal short (shorter than basioccipital); interparietal broader than long, normally oval or elliptical and projecting posteriorly behind plane of lambdoid suture; occiput bulging posteriorly more than in any other United States species (resembling *Pappogeomys bulleri* and some species of *Thomomys*).

Skulls of *texensis* differ conspicuously from those of *G. arenarius* in the following points: Nasal branches of premaxilla longer and more pointed posteriorly; jugal more slender; no distinct knob at end of squamosal arm of zygoma; no distinct temporal ridges; interparietal projecting posteriorly behind plane of lambdoid suture; occiput more bulging posteriorly; mandible less heavy. *G. texensis* differs from *G. breviceps* in the shape of the nasal bones which are usually short, very broad posteriorly, with the sides nearly parallel. In *G. breviceps* they are usually longer, strongly wedge shaped, very narrow posteriorly, with the anterior third abruptly broader and flaring. In *texensis* the nasal branches of the premaxilla reach or pass the plane of the orbital

fossa and are pointed; in *breviceps* they usually fall short of this plane and are bluntly rounded. In *texensis* the jugal is shorter than the *basioccipital*; in *breviceps* it is longer. In *breviceps* the outer angle of the zygomatic arch is evenly rounded; in *texensis* it is angular and abruptly flattened (or even excavated) on its infero-external face, beginning at the angle and extending posteriorly under the jugal (as seen from the side). The inflated mastoids and audital bullæ are larger in *breviceps*, in which species the mastoids are conspicuously broader than in *texensis*, the exposed part, viewed from behind, being as broad as high, while in *texensis* the breadth is only about half the height. But the range of individual variation is so great that much confidence can not be placed on this character.* In *breviceps* the frontal is flatter and depressed interorbitally, forming a slight concavity in the plane of the upper side of the skull when seen in profile; in *texensis* the profile is convex at this point.

Skulls of *Geomys texensis* differ from those of *G. bursarius*, in addition to their much smaller size, in shorter rostrum and brain case, less prominent ridges and processes for muscular attachments, absence of sagittal and lambdoidal crests at all ages; much larger interparietal; much larger audital bullæ (which are inflated and rounded antero-laterally instead of flattened), and in the greater length of the ascending branches of the premaxilla posteriorly. The skull as a whole is not only much smaller than that of *bursarius*, but is relatively thin and smooth, like that of *Thomomys*. The arch of the brain case is low, but not so flat as in *breviceps*, and the temporal impressions never meet along the median line.

Measurements.—Type specimen: Total length, 203 (measured in flesh); hind foot, 28 (in dry skin moistened to straighten the toes). Tail not measured in flesh, but short; about 60 in dry skin. Average total length of 28 specimens from type locality measured in flesh, 210.

For cranial measurements see Table B, p. 206.

Specimens examined.—Total number 31, from the following localities in Texas: Mason, Mason County (type locality), 28; Laredo, 1; Sycamore Tree (on Rio Grande), 1; Del Rio (on Rio Grande), 1.

General remarks.—*Geomys texensis* is a small white-bellied species inhabiting central Texas. Its back is chestnut-brown or liver-brown, much as in the large dark-bellied *G. bursarius*, with which it requires no comparison. It is the smallest species in the United States, about equaling *Pappogeomys bulleri* of Mexico. The only bisulcate species of approximately the same size are *G. breviceps* of Louisiana and its subspecies *sagittalis* of the Gulf coast of Texas, and *G. arenarius* of the Upper Rio Grande Valley in extreme western Texas and south-cen-

* The actual size of the mastoid is often hidden by the thin outer edge of the exoccipital which overlies its inner border, and which is not always alike on the two sides. Hence it sometimes happens that the exposed part of the mastoid is narrow on one side and broad on the other.

tral New Mexico, with all of which it may intergrade, although it differs widely from them all in color and cranial characters, as elsewhere shown. On the north, in Oklahoma and southern Kansas, it probably intergrades with *G. lutescens.*

Three specimens of a small *Geomys* from as many points in the Rio Grande Valley (Laredo, Del Rio, and Sycamore Creek) are provisionally referred to the present species. The Laredo specimen lacks the skull and its upper parts are more drab than usual. The specimens from Del Rio and the mouth of Sycamore Creek are too immature for positive identification. They differ from the young of *texensis* from the type locality in having longer tails, somewhat darker backs, and in lacking the chestnut tint on the sides. Their skulls seem to be intermediate between *texensis* and *arenarius.* Mr. William Lloyd, who collected the Sycamore Creek specimen, states that the species is rare there and was found only in a belt of fine sand along the Rio Grande. He found a species, presumably the same, on chalky soil near Comstock. Mr. Vernon Bailey collected the Del Rio specimen in the river bottom, where the species was rather rare.

GEOMYS ARENARIUS sp. nov.

(Pl. 9, fig. 1; pl. 13, fig. 13.)

Type from El Paso, Texas. No. $\frac{18117}{25015}$ ♂ ad. U. S. National Museum, Department of Agriculture collection. Collected December 13, 1889, by Vernon Bailey (Original No. 798).

Geographic distribution.—Valley of the Upper Rio Grande, from El Paso, in extreme western Texas, and Juarez, Chihuahua (on the Mexican side of the river opposite El Paso), north to Las Cruces, New Mexico, and west to Deming, in the same state (map 4, G). It will probably be found to follow the valley somewhat further in both directions, and to the east may intergrade with *texensis.* So far as now known its range seems to be separated by a broad interval from that of the species inhabiting central and southern Texas, the westernmost records of which are Del Rio and Comstock, in the Rio Grande Valley. Curiously enough the intervening region is inhabited by a widely different Pocket Gopher, one belonging to the unisulcate series, namely, *Cratogeomys castanops.* The ranges of all the other bisulcate species, except *tuza*, are either directly continuous or contiguous. In faunal position *G. arenarius* belongs to the upper edge of the Lower Sonoran Zone.

General characters.—Size medium; tail rather long and unusually well haired, except near tip; coloration pale.

Color.—Upper parts drab-brown, finely mixed with black-tipped hairs; under parts and feet white. In some specimens the color of the sides encroaches on the belly and is only partly masked by the white tips of the hairs.

Cranial characters.—Skull resembling *Thomomys talpoides;* size rather small (intermediate between *texensis* and *breviceps*); zygomata normally

narrow and nearly parallel (in one ♂ from El Paso, No. 58340, they are exceptionally divergent anteriorly); no sagittal crest at any age; temporal ridges prominent, distant, and nearly parallel or slightly divergent anteriorly, usually separated by a flat or concave interspace 4 to 5 mm wide, as in *Thomomys talpoides;* squamosal arm of zygoma ending in a prominent knob over middle of jugal (diagnostic of the species); jugal short (shorter than basioccipital); interparietal rather large, normally (but not always) broader than long, usually subquadrangular or with the corners rounded anteriorly, truncate posteriorly on plane of lambdoid suture; occiput bulging posteriorly, but not so far as in *texensis;* palatopterygoids normally abruptly narrow, their sides nearly parallel (but form somewhat variable); mandible heavy for size of skull. The females differ from the males in having shorter nasals, larger parietals, and less prominent temporal ridges. As a rule the interspace is somewhat thickened and the ridge is evident from the outer side only.

The skull of *G. arenarius* differs from that of *texensis* in the following characters: Jugal heavier and broader; temporal ridges much more prominent and distant; a prominent knob at distal end of squamosal arm of zygoma; top of skull flatter; frontal broader and flatter interorbitally; interparietal truncate posteriorly on plane of lambdoid suture; occiput less bulging. It differs from *lutescens* in much smaller size, narrower and more parallel zygomata; shorter jugal; in the presence of well-developed distant temporal ridges, and of a prominent knob at distal end of squamosal arm of zygoma; shorter and somewhat narrower nasals, and shorter ends of ascending arms of premaxilla behind the nasals.

Measurements (taken in flesh).—Type specimen (♂ ad.): Total length 258; tail vertebræ, 88; hind foot, 33. Average of 8 males from type locality: Total length, 260; tail vertebræ, 83; hind foot, 32. Average of 24 females* from type locality: Total length, 250; tail vertebræ, 78; hind foot, 32.

For cranial measurements see Table B, p. 207.

Specimens examined.—Total number 43, from the following localities: Juarez, Mexico, 3; El Paso, Texas, 30; Deming, New Mexico, 3; Las Cruces New Mexico, 7.

General remarks.—In color and external appearance *Geomys arenarius* closely resembles the typical form of *G. lutescens* (from western Nebraska and eastern Wyoming), differing chiefly in smaller size and in greater length and hairiness of tail. From its nearest ally in central Texas (*G. texensis*) it differs both in color and proportions, having the upper parts pale drab instead of reddish brown, and the tail long and hairy instead of short and nearly naked. In cranial characters it may be distinguished from all other species by the presence of distant tem-

*Some of the specimens recorded as females are very large and were probably males; hence the averages here given for females are probably too great.

poral ridges or ribs, which are nearly parallel, in connection with the development of a prominent knob at the distal end of the squamosal arm of the zygoma.

This fine species was discovered by my assistant, Mr. Vernon Bailey, at El Paso, Texas, in December, 1889, and was obtained by him at Deming, New Mexico, also. Mr. J. Alden Loring, who was sent to the Upper Rio Grande Valley to work out its range, secured a large series from Las Cruces, New Mexico, and Juarez, Chihuahua, Mexico, as well as at the type locality, El Paso, Texas. Mr. Loring says: "They are not very common on the Mexican side of the river, but extremely so on American soil, where they seem to thrive and grow fat. The places they most prefer are railroad embankments and irrigation ditches, where they were found both in sand and wet, dark clayey soil. Two were seen on February 5 just as they protruded their heads from their holes. Their faces were covered with dirt, and as soon as they had shaken it off they saw me and quickly dodged back. When these Gophers were caught I noticed that they walked with the claws of the front feet partially doubled under, which did not allow the sole of the foot to touch the ground."

GEOMYS PERSONATUS True.

(Pl. 12, fig. 4; pl. 13, fig. 14; pl. 14, fig. 4.)

Geomys personatus True, Proc. U. S. National Museum, XI (for 1888), Jan. 5, 1889, 159–160.

Type locality.—PADRE ISLAND, TEXAS.

Geographic distribution.—The Tamaulipan fauna of Texas, comprising Padre Island and the adjacent mainland southwesterly to Carrizo on the Rio Grande (map 4, F).

General characters.—Size large; coloration pale; tail long, scant-haired on proximal half and nearly naked on distal half.

Color.—Upper parts pale drab (darker in winter from more liberal admixture of dark-tipped hairs); middle of face from nose to above eyes inclining to dusky. Under parts white, sometimes obscurely clouded, from the presence of irregular patches of hairs with plumbeous bases, the hairs on other parts of the belly white to roots. Tail hairs white, but too far apart to give color to the nearly naked tail.

Cranial characters.—Skull large, heavy, with well-developed processes and ridges and a high sagittal crest (pl. 12, fig. 4); zygomata standing out at right angle to axis of skull; jugal bluntly and broadly rounded anteriorly, and short, not longer than basioccipital (measured from condyle); nasals long and narrow, anterior third spreading; frontal narrow interorbitally, the orbital borders rounded; basioccipital with sides parallel, or nearly parallel. In profile the top of the skull (including the sagittal crest) is nearly a straight line.

Adult skulls of *Geomys personatus* may be easily distinguished from those of *bursarius* and *lutescens* by the squareness of the zygomatic

arches anteriorly, the shortness of the jugal bone anteriorly, with corresponding production of the maxillary arm of the zygoma. The greatest length of the jugal in *personatus* is only equal to the length of the basioccipital bone (measured from the condyle). In both *bursarius* and *lutescens* the jugal is much longer than the basioccipital. In *personatus* the skull as a whole is relatively as well as actually longer, and narrower across the zygomatic arches, than that of *lutescens*, from which it differs further in the following particulars: zygomatic breadth usually less than distance from foramen magnum to incisive foramina (the contrary being usually true in *lutescens*); ascending branches of premaxilla extending much further posteriorly; zygomatic arches relatively long, only moderately spreading anteriorly (except in extreme age), but standing out at right angle to longitudinal axis of skull; orbital fossæ elongated antero-posteriorly instead of subtriangular; length of frontal along median line usually equal to length of nasals (commonly shorter in *lutescens*); audital bullæ longer, with outer side flattened; inflated mastoid smaller. Skulls of *personatus* average longer in proportion to the zygomatic breadth than those of any other known bisulcate species, except the Mexican *Zygogeomys trichopus* (the ratio of zygomatic breadth to basilar length ranging from 68 to 72 percent), though in this respect they differ but slightly from *Geomys bursarius*.

Measurements.—Of 13 specimens (of both sexes) from type locality (Padre Island): Total length, 399; tail vertebræ, 103; hind foot, 37. Average of 4 males: Total length, 315; tail vertebræ, 111; hind foot, 40. Average of 9 females: Total length, 293; tail vertebræ 100; hind foot, 36.

For cranial measurements see Table B, p. 206.

Specimens examined.—Total number 33, from the following localities on or near the Gulf coast of Texas: Padre Island (type locality), 15; near Santa Rosa, 8; Sauz Rancho, 6; Carrizo, 3.

Number of subspecies *fallax* 22, as follows: Nueces Bay and River (south side), 6; Corpus Christi, 15; Las Mottes, 1.

Departures from the type.—The type locality of *Geomys personatus* is Padre Island. Fairly typical specimens are at hand from points on the mainland west of the southern part of this island, namely, Santa Rosa and the Arroyo Colorado (Sauz Rancho), and also from Carrizo on the Rio Grande, though the latter depart somewhat from the type. Singularly enough, specimens from the lower Nueces River and Bay, and from Corpus Christi and Las Mottes, differ decidedly from the typical animal in smaller size, darker color, and in important cranial characters. The skull is much smaller, more abruptly truncate posteriorly, with more spreading zygomatic arches, and much more globular audital bullæ (pl. 12, fig. 3). This form is here separated sub-specifically under the name *Geomys personatus fallax* (see p. 144). Intergradation between *personatus* and *fallax* probably occurs in the narrow strip between Santa

Rosa and Corpus Christi Bay, since the single specimen from Las Mottes, a few miles south of Nueces Bay, is somewhat larger than the Nueces Bay and Corpus Christi specimens.

Some of the specimens from Santa Rosa are fairly typical *personatus*, though all have more swollen audital and mastoid bullæ. One adult skull (No. 42,860) from the Arroyo Colorado (Sauz Rancho, about 50 miles north of Brownsville) has a very narrow rostrum, narrow zygomata, projecting occiput, very much swollen mastoid and audital bullæ (the latter almost subglobular) and abnormally short and narrow jugal. Five other skulls from the same locality are young and apparently less extreme. The adult skull may be regarded as abnormal, or as pointing to the differentiation of an incipient race.

General remarks.—Geomys personatus resembles *G. lutescens* in summer pelage more closely than any other form. The typical animal may be distinguished from *lutescens* at all seasons by larger size, longer feet and tail, by important cranial characters (just described in detail), and by the white of the under parts. In summer specimens of *G. lutescens* the belly is sometimes pale, but rarely white except in the very young. The color of the upper parts in summer pelage differs but little in the two species, being drab in both, with the nose and middle of the face, as far back as the eyes, inclining to dusky; but in winter and early spring the two differ notably, the dusky face markings of *lutescens* extending posteriorly over the head and back to the rump, forming a distinct dorsal stripe. In this pelage, also, the under parts are much darker, the fur being dark plumbeous, tipped with drab. While *personatus* is the larger of the two animals, the claws of the fore feet are equally large (and relatively larger) in *lutescens*. In some specimens of *personatus* the claws are remarkably long and slender—the result, doubtless, of the unresisting character of the sand in which the animals live.

The geographic distribution of *Geomys personatus* (including subspecies *fallax*) appears to coincide with the limits of the arid tropical area of Texas—an area recognized and defined by me in 1892,* and subsequently named the *Tamaulipan fauna* by Allen.† The range of the species has been ascertained to terminate abruptly both on the north and on the west, specimens from a few miles north of Corpus Christi Bay, and from Laredo on the Rio Grande, belonging to different species.

Mr. William Lloyd, who collected the specimens, states that *G. personatus* is abundant in a patch of fine sandy soil above Carrizo, but was not found elsewhere in the neighborhood. He states further that in traveling north from the mouth of the Rio Grande it was first met on entering the great sand belt on the north side of the Arroyo Colorado (at El Sauz). It continued throughout this sand belt, becoming more abundant to the northward. On Padre Island he found the animals living in colonies, perhaps a mile or more apart, and common from the

* Presidential Address, Proc. Biol. Soc., Washington, April, 1892, p. 33.

† Bull. Am. Museum Nat. Hist., New York, Vol. IV, Jan., 1893, 241–242.

north end to the center of the island, but not within 20 miles of the south end. Mr. Lloyd says: "Their habits are in some respects peculiar, owing perhaps to the soft sand that caves in on them, or to fear of the coyotes, or for both reasons; they fill up their tunnels for a yard or two almost immediately after they throw out the dirt. They can not go very deep in the flats or they would reach water; in fact, the water filled some of the tunnels for about a foot until they curved upward. Not more than one is ever found in a hole."

GEOMYS PERSONATUS FALLAX subsp. nov.

(Pl. 12 fig. 3.)

Type from south side of NUECES BAY, TEXAS. No. $\frac{32031}{43845}$ ♂ ad. Collected November 30, 1891; by William Lloyd. (Original No. 949.)

Geographic distribution.—South shore of Nueces Bay and lower Nueces River, Texas; further south passing into *G. personatus*.

General characters.—Similar in external appearance to *G. personatus* of Padre Island, but much smaller (only about half the bulk of that species); somewhat darker; tail shorter and nearly naked.

Color.—Upper parts drab-brown, darker in winter; paler and more fulvous in summer; nose and face between eyes dusky; sometimes an ill-defined dusky band along the middle of the back. Under parts usually marbled with pure white and patches of dark hair (the white hair being white to roots).

Cranial characters.—Skull similar to that of *personatus*, but very much smaller (pl. 12, fig. 3). The zygomata stand out squarely at right angles to axis of cranium and are widely spreading, their outer sides nearly parallel; the temporal impressions meet in the males in a well-marked sagittal crest; in the females they remain apart, separated by an interspace about 3 millimeters wide; nasals rather broad and blunt posteriorly; jugals short (not longer than basioccipital); mastoid and audital bullæ swollen, the latter short and rounded; palatopterygoids narrow, their sides nearly parallel. Skulls of *fallax* differ from those of *personatus* in very much smaller size, shorter (and usually blunter) ascending arms of premaxilla, more squarely truncate occiput (lambdoid crest less convex posteriorly), and in much shorter and more swollen audital bullæ.

Geomys personatus fallax differs markedly from *G. attwateri* (which it approaches in size) in the form of the zygomata, the maxillary arm standing out at right angle instead of sloping strongly backward, and the outer sides of the arches being nearly parallel instead of strongly divergent anteriorly. It differs further in having more globular audital bullæ, broader nasals, narrower ascending branches of the premaxilla, and in the males a well-developed sagittal crest instead of permanent temporal ridges.

Measurements.—Type specimen: Total length, 250; tail vertebræ, 80; hind foot, 35. Average of 9 males from south side of Nueces Bay: Total

length, 263; tail vertebræ, 87; hind foot, 34. Average of 10 females from same locality: Total length, 236; tail vertebræ, 75; hind foot, 31.

For cranial measurements see Table B, p. 206.

Specimens examined.—Total number 32, from the following localities on or near Nueces Bay, Texas: Nueces Bay, 4; Nueces River, 10 miles from mouth, 2; Corpus Christi 15; Las Mottes, 1.

General remarks.—*Geomys fallax* is a miniature of *G. personatus*, both in external appearance and in the general form of the skull. It is hardly more than half the bulk and weight of *personatus*, from which it differs further in somewhat darker coloration and in cranial details. The geographic range of the typical form is remarkably restricted, being limited, so far as known, to the south side of the lower Nueces River and Bay.

In his notes on mammals observed in southeastern Texas, Mr. William Lloyd states that this species "is abundant in all soils, although it prefers the black loam. On Nueces Bay they burrow in the sand close to the water's edge, but are most at home on the highest point attainable. I have seen an unbroken line of hills extending from 70 to 100 yards across patches of early pease and onions. They cause havoc among the sweet potatoes, coming above ground to eat them in the daytime. I shot a marsh hawk that was flying off with a gopher which had been thus engaged. While driving along the road cats may be seen frequently a mile from the house intently watching the gophers' holes. The gophers are known to be great pests to fruit and other trees; in more than a dozen instances near the bay I have seen the huisachi (*Acacia farnesiana*) leveled by their work in chewing the rootlets and digging the earth away from the roots."

Genus PAPPOGEOMYS * nob.

(Pl. 11, fig. 1; and text figs. 56, 57 and 58.)

Type *Geomys bulleri* Thomas, from TALPA, MASCOTA, JALISCO.

Dental characters.—Upper premolar with three enamel plates, the posterior absent; m^1 and m^2 with two enamel plates each, as in *Geomys*. Last upper molar an imperfectly double prism; a single sulcus on outer side, behind which the crown is narrowed, forming a moderately well-defined heel; outer enamel plate bent slightly outward near its anterior end. Upper incisor unisulcate, the sulcus median and deep (no trace of minor sulcus; see fig. 21[4]).

Cranial characters.—Skull small, short, rather smoothly rounded; a broad sagittal area (no sagittal crest at any age, pl. 11, fig. 1); zygomata slender, rather broadly and squarely spreading, without trace of angular expansion; occiput bulging posteriorly; palatopterygoids little

***Pappogeomys*, from πάππος, grandfather, + *Geomys*, in reference to the apparent antiquity of the type.

more than vertical lamellæ, slightly everted inferiorly; orbital plates of frontal separated inferiorly by full breadth of cribriform plate as in *Thomomys;* orbitosphenoids broad, articulating firmly with alisphenoids and sending a tongue upward to nearly fill the upper part of the sphenoidal fissure; mesethmoid a nearly vertical plate much higher than long, its inferior edge dipping down between wings of vomer posteriorly; endoturbinals as in *Platygeomys*, the first sharply triangular and the os planum trimmed closely in front of the others.

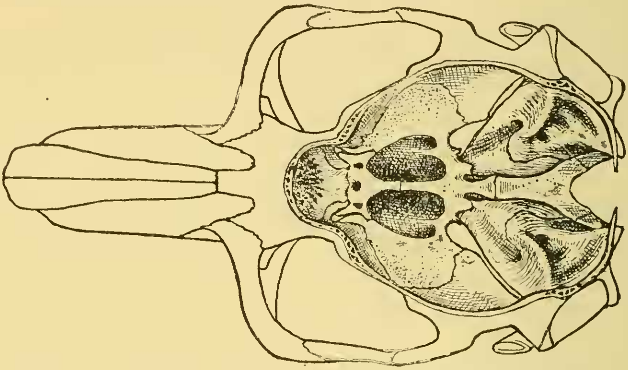

FIG. 56.—*Pappogeomys bulleri.* Vault of cranium sawed off, showing floor of brain case. (For key see fig. 9).

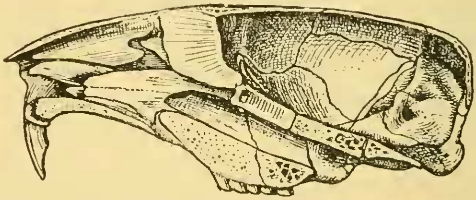

FIG. 57.—*Pappogeomys bulleri.* Vertical longitudinal section of skull, mesethmoid and vomer in place. (For key see fig. 7).

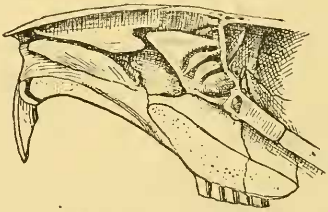

FIG. 58.—*Pappogeomys bulleri.* Mesethmoid and vomer removed to show endoturbinals. (For key see fig. 10).

External characters.—Size small; pelage soft; form *Thomomine.*

General remarks.—*Pappogeomys* holds an interesting position with eference to the trunk line of the *Geomyidæ.* In dental characters it combines the molariform enamel pattern of *Geomys* with the unisulcate incisors of *Cratogeomys* and *Platygeomys;* and in cranial characters it

exhibits striking resemblances to both *Geomys* and *Thomomys* on the one hand, and to *Cratogeomys* on the other. The endoturbinals are not widely different from the *Geomys* type, while the orbitosphenoids depart entirely from *Geomys* and surpass *Cratogeomys* in the extent of their development and articulations. They cut off and shorten the sphenoid fossæ, which in *Geomys* reach forward to the orbital plates of the frontal (pl. 17, fig. 3). The shape of the mesethmoid plate is unique. The form of the skull as a whole is very like the simpler forms of *Thomomys* and *Geomys*—as *texensis* and *arenarius*—and the permanently distant orbital plates of the frontal is a decidedly Thomomine character.

The resemblances to *Geomys* and *Thomomys* do not indicate that *Pappogeomys* has descended from either of these genera, but that it occupies a place near the trunk line and below the point from which they branched off. On the other hand, the resemblances to *Cratogeomys* and *Platygeomys* are prophetic, indicating a position near the base of the great branch that afterward gave rise to these more specialized types.

KEY TO SPECIES OF PAPPOGEOMYS.

Mastoids small, truncate above.......................................*bulleri*.
Mastoids large, rounded above ....*albinasus*.

PAPPOGEOMYS BULLERI (Thomas).

(Pl. 11, fig. 1; pl. 13, fig. 15; pl. 14, fig. 11.)

Geomys bulleri Thomas, Annals and Magazine Nat. Hist., 6 series, Vol. x, August, 1892, p. 196.
Geomys nelsoni Merriam, Proc. Biol. Soc., Washington, VII, September 29, 1892, 164–165.

Type locality.—Near TALPA, WEST SLOPE OF SIERRA DE MASCOTA, JALISCO, MEXICO (altitude, 8,500 feet). Type in British Museum.

Geographic distribution.—Lower slopes of Sierra Nevada de Colima and Sierra de Mascota, Jalisco, Mexico (map 3[1]).

*General characters.**—Size smallest of the known unisulcate species, of which it is a generalized type; skull small and smooth, resembling *Thomomys;* tail naked; a naked pad on end of nose, partly inclosed in a pale patch.

Color.—Upper parts rich rusty chestnut; underparts paler. An immature but full-grown specimen (No. 33585) is dusky in color, and one in the molt has the anterior parts chestnut and the posterior dusky.

Cranial characters.—The skull of *Pappogeomys bulleri* is small and smoothly rounded, with broadly distant and rather feeble temporal ridges. The maxillary arms of the zygomata stand out at right angles

* The following description is based wholly on specimens from the north slope of the Sierra Nevada de Jalisco. They are larger than Thomas's type and only specimen of *G. bulleri*, and may prove subspecifically separable, in which case the name *nelsoni* will be available.

to the axis of the skull; the zygomata are slender, rather widely spreading, without trace of expanded angle, and their outer sides are nearly parallel (sometimes broader posteriorly than anteriorly). The occiput bulges far behind the lambdoid suture and is smoothly rounded (except in old males, in which it is less inflated and is marked by a median vertical ridge). In all of these respects it agrees with the closely related *P. albinasus* and differs from all other known Mexican species. The frontal is broad and rather flat interorbitally; the nasals narrow and truncate posteriorly; the ascending branches of the premaxilla short, bluntly rounded posteriorly, and barely reaching plane of orbits. The pterygoids are parallel lamellæ, their inferior edges slightly everted—a transition step in the development of the horizontal shelf of *Cratogeomys* from the simple lamella of *Thomomys*. The hamular processes articulate directly with the audital bullæ. *P. bulleri* differs from the nearly related *P. albinasus* in smaller size, smaller mastoids (which are truncate above instead of rounded), narrower rostrum, narrower and longer nasals, narrower ascending branches of premaxilla, and much shorter angular process of mandible.

Dental characters.—Upper incisors narrow, with a single median furrow; molariform series only slightly heavier than in *G. texensis;* last upper molar with a large heel, which equals or exceeds the anterior prism in antero-posterior diameter.

Measurements.—Average of 2 males from north slope of Sierra Nevada de Colima, Jalisco (measured in flesh): Total length, 236; tail vertebræ, 81.5; hind foot, 33. Average of 4 females from same locality: Total length, 215.5; tail vertebræ, 72.5; hind foot, 30.*

For cranial measurements see Table F, p. 214.

Specimens examined.—Six, all from the north slope of the Sierra Nevada de Jalisco, Mexico.

General remarks.—This species was described almost simultaneously by Mr. Oldfield Thomas and myself, but his description has priority of publication by about a month. Hence his name, *bulleri*, has precedence over my *nelsoni*. Mr. Nelson states that the species "was found only in some fields at the upper ranch at the foot of the main north slope of the Sierra Nevada de Colima, Jalisco, in the upper border of the lower pine belt, at about 6,500 feet altitude, where it was common, and was found in company with the large species, *Geomys gymnurus*."

Pappogeomys bulleri greatly resembles the bisulcate *Geomys texensis*, from which its dental characters distinguish it at a glance. It is evident that both *bulleri* and *texensis* have undergone but little modifica-

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* In my original description of *G. nelsoni*, the measurements were taken "from dry skin of type [♂], slightly overstuffed," the field measurements not having been received (Proc. Biol. Soc., Washington, VII, Sept. 29, 1892, 164.) The measurements as published were: Total length, 250; tail vertebræ, 80; hind foot, 30. The flesh measurements of the same specimen are: Total length, 238; tail vertebræ, 83; hind foot, 33. Mr. Thomas' measurements of his type specimen of *bulleri* are: Head and body, 135; tail, 63; hind feet, with claw, 27.6.

tion since they left the main trunk line of the group, and that both branched off from points not very remote from the place where *Thomomys* left the same stock.

PAPPOGEOMYS ALBINASUS sp. nov.

Type from GUADALAJARA, STATE OF JALISCO, MEXICO. No. $\frac{34138}{46215}$ ♀ ad. U. S National Museum, Department of Agriculture collection. Collected at Atemajac, a suburb of Guadalajara, May 21, 1892, by E. W. Nelson (Original No. 2654).

Geographic distribution.—The plain of Guadalajara; limits of range unknown. Mr. Nelson states: "This species occurs very sparingly on the open plain about Guadalajara, and diggings of a small gopher, probably the same species, were seen near Ahualulco, some 35 miles farther west. The range in altitude of these localities lies between 4,000 and 5,100 feet."

General characters.—Size small; naked nasal pad well developed; tail naked. Animal similar to *P. bulleri* of Thomas, but somewhat larger; nasal pad and white patch above it more elongated; color paler; whiskers finer and less conspicuous.

Color.—Uniform pale plumbeous above and below, irregularly washed with pale chestnut, palest below; a small dark patch around each ear; an elongated white patch on nose inclosing nasal pad and reaching posteriorly nearly to plane of eyes.

Cranial characters.—Skull small, smoothly rounded like *Thomomys;* zygomatic arches parallel, slender, angle not expanded; temporal impressions widely distant; zygomatic breadth slightly exceeding greatest breadth of cranium posteriorly. Skull similar to that of *P. bulleri*, but differing in larger size; much larger mastoids, which are rounded above instead of truncate; broader muzzle; shorter and broader nasals; broader ascending branches of premaxilla, and more elongated angular processes of mandible.

Measurements in flesh.—Type specimen ♀ ad. Total length, 226; tail vertebræ, 68; hind foot, 31.

For cranial measurements see Table F, p. 214.

General remarks.—The only known species requiring comparison with *P. albinasus* is the related *P. bulleri* of Thomas, a smaller and much more highly colored animal, differing in the cranial characters above pointed out. Future investigations may show that the ranges of the two meet, and that the animals intergrade, in which case *albinasus* will become a subspecies of *bulleri*.

Unfortunately, only a single specimen of *Pappogeomys albinasus* is at hand. But since its type locality, Guadalajara, is an attractive and accessible locality. It is probable that a large series of specimens will be obtained in the near future.

Genus CRATOGEOMYS * nob.

(Pl. 2; pl. 10, fig. 5; pl. 12, figs. 1 and 2; pl. 13, figs, 4–8, and 17; pl. 14, figs. 6 and 7; pl. 15, figs. 6 and 9; pl. 17, fig. 5; pl. 18, fig. 4; pl. 19, fig. 6.)

Type *Geomys merriami* Thomas, from the VALLEY OF MEXICO (pl. 2).

Dental characters.—Upper premolar with three enamel plates (the posterior absent), its shaft strongly convex forward; upper and lower premolars subequal in length. First and second upper molars with one enamel plate each (posterior absent); posterior curvature of m^1 and m^2 and anterior curvature of m_1 and m_2 strong.

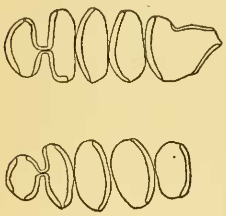

FIG. 59.—*Cratogeomys merriami.* Crowns of molariform teeth: *a*, upper; *b*, lower.

Last upper molar an imperfectly double prism; a deep sulcus on outer side; no sulcus on inner side; crown of tooth normally broader than long, variable in form, usually more or less obcordate or subtriangular; inner and outer enamel plates variable; inner plate normally at least two-thirds as long as anterior plate, obliquely transverse, normally covering posterior face of tooth.

Upper incisor with a single sulcus, median or slightly on inner side, and usually rather open (fig. 21[1], 21[3], and pl. 15, fig. 9).

Cranial characters.—Skull large and massive; zygomata heavy and rather broadly spreading; orbitosphenoids short and broad, articulating with alisphenoids anteriorly; mesethmoid a half crescent, its apex pointing to presphenoid; endoturbinals together forming a compact plate, strongly convex below, straight above, its anterior border sloping strongly backward without any extension of the os planum in front of the folds (pl. 19, fig. 6); first endoturbinal moderately expanded and elongated; second, third, and fourth subequal; vomerine edge of os planum curving down below plane of roof of narial passage; floccular fossa circumscribed and separated from internal auditory meatus by a distinct ridge; ridge separating inner from superior face of petrous sharp and incurved, and sometimes rising high posteriorly (pl. 17, fig. 5, and pl. 18, fig. 4).

The following additional characters, of more or less weight, are introduced with special reference to antithesis with *Platygeomys:* † Breadth of cranium posteriorly (above mastoids) much less than zygomatic breadth; breadth of occipital plane not more than twice its height; lambdoid crest broadly convex posteriorly; squamosal expansion chiefly toward the median line (in *C. merriami* in advanced age they completely cover and conceal the parietals, above which they meet in a median crest); mandible longer than broad (including incisors); angular process

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* *Cratogeomys*, from κράτος, strong, powerful, + *Geomys*, in reference to the great size and strength of the animals.

† Many of the characters already given in the generic diagnosis are also in strong contrast to those of *Platygeomys*.

of mandible short, nearly sessile, truncated externally, and forming a shelf completely around the base of the outer side of the incisor knob; squamosal arm of zygoma covering nearly or quite two-thirds of jugal, which latter fills but a narrow gap in zygomatic arch (except in one species, *C. fulvescens*, in which the jugal is abnormally short posteriorly, its anterior relations being normal); free part of upper edge of jugal half or less than half the length of basioccipital on median line; paroccipital processes relatively light; incisors heavy in contrast to those of *Platygeomys* (except in *fulvescens* and *castanops*); antero-posterior diameter of incisors greater than transverse (except in *fulvescens* and *castanops*); enamel face of lower incisors forming a conspicuous bead on outer side of tooth, behind which the tooth is strongly beveled, the transverse diameter being much greater through the enamel face than posteriorly (except in *fulvescens* and *castanops*).

In *Cratogeomys* a marked depression extends obliquely across the squamosals from the root of the zygoma to the occiput near the median line. In the *gymnurus* series no such depression exists, but, on the contrary, a distinct bulge or elevation occupies this part of the skull.

Cratogeomys splits naturally into two sections: The *merriami* series, comprising *merriami*, *perotensis*, *estor*, *oreocetes*, and *peregrinus;* and the *castanops* series, comprising *castanops* and *fulvescens*. In the *merriami* series the top of the skull seen in profile is a nearly straight line; the zygomata are not strongly decurved, and the outer angle is only moderately expanded. In the *castanops* series the top of the skull is decidedly convex, the zygomata are strongly decurved, and the outer angle is broadly expanded. Numerous other cranial differences exist, and it is probable that the *castanops* series will be eventually separated, at least subgenerically, from *Cratogeomys* proper.

KEY TO SPECIES OF CRATOGEOMYS.

(1) BASIOCCIPITAL *rectangular, its sides parallel*

  Rostrum and brain case long .... *castanops*

  Rostrum short; brain case broad .... *goldmani*

(2) BASIOCCIPITAL *truncate wedge-shaped* (sides approximating anteriorly).

  a[1] *Sagittal crest well developed.*

    b[1] Lower incisor strongly beveled on outer side .... *merriami*

    b[2] Lower incisor not beveled on outer side.

      c[1] Top of skull strongly convex in profile .... *fulvescens*

      c[2] Top of skull nearly flat in profile.

        Nasals normal (rather long and narrow) .... *perotensis*

        Nasals short, narrow posteriorly and broad anteriorly .... *estor*

  a[2] *No sagittal crest.**

    Outer face of upper incisor strongly beveled .... *oreocetes*

    Outer face of upper incisor not beveled .... *peregrinus*

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*The only specimens seen of *oreocetes* and *peregrinus* are females; it is possible that the old males may have a crest.

CRATOGEOMYS MERRIAMI (Thomas).

(Pl. 2; pl. 10, fig. 5; pl. 13, fig. 4; pl 14, fig. 7; pl. 15, figs. 6 and 9; pl. 17, fig. 5; pl. 18, fig. 4; pl. 19, fig. 6).

Geomys merriami Thomas, Annals & Magazine Nat. Hist., Ser. 6, Vol. XII, October, 1893, 271-273. (Type in British Museum.)

Type from "southern Mexico"—probably the VALLEY OF MEXICO.

Geographic distribution.—South end of Valley of Mexico and adjacent mountain slopes from just below the lower edge of the lower pine belt up to an altitude of 10,000 or 11,000 feet; east to Atlixco (Puebla), north to Irolo (Hidalgo), and west to Lerma, in Toluca Valley (map 4, I).

General characters.—Size largest of the genus *Cratogeomys;* tail and hind feet moderately haired but not so well covered as in *C. fulvescens;* skull massive; incisors huge.

Color.—Upper parts dull chestnut brown, mixed with black-tipped hairs, varying to glossy slate black; underparts similar but paler; the rusty specimens have a dark patch around and behind each ear, which is not apparent in the slate-black ones.

Cranial characters.—Skull large and massive, the zygomatic arches widely spreading anteriorly and rapidly narrowing posteriorly (pl. 2); incisor teeth larger and heavier than in any known Mexican species, not excepting *Platygeomys gymnurus;* antero-posterior diameter of incisors much greater than transverse; lower incisors with a strongly marked bevel on the outer side immediately behind the enamel; behind the bevel the tooth is abruptly narrower; outer edge of enamel forming a conspicuous bead. In adult males the squamosals completely cover the parietals and meet in a median crest above the sagittal crest proper. The mandible of the Lerma skull (No. 50110) is longer and narrower across the angular processes than that of specimens from the slopes of the Valley of Mexico. Skulls from Irolo differ from the typical form of the Valley of Mexico in having the mastoids considerably larger and fuller posteriorly, occupying more of the occipital plane. The audital bullæ also are somewhat more swollen. The mastoids do not extend out so far laterally as in typical *merriami;* the postpalatal pits are not so deep; the coronoid processes of the mandible are more spreading (directed more strongly outward), and the heel of the last upper molar is shorter. The Irolo skulls agree with typical *merriami* and differ from the Atlixco specimens in having the frontal reach further forward along the median line than on the sides. Skulls from Atlixco differ from typical *merriami* in the following particulars: The nasals extend further back, reaching or passing plane of fronto-maxillary suture; the frontal reaches as far forward laterally as on median line (in *merriami* it reaches much further forward on median line); as a rule the coronoid processes of mandible are lower and more abruptly curved backward, with the coronoid notch correspondingly narrower.

The massiveness of the incisor teeth in true *merriami* is much more extreme than in any of the other species, and is coördinated, as already

pointed out, with a much greater development of the squamosal and of the various prominences and ridges for muscular attachment.

Variations in pelage.—*Cratogeomys merriami* exhibits both the melanistic and chestnut color phases, and also intermediate pelages. In four adult specimens from Tlalpam, three are dark brown, faintly washed with fawn color or very pale fulvous; the fourth is bright chestnut or reddish-brown on the rump and sides, while the newer hair of the back is intimately mixed with blackish. One specimen from Amecameca has a white spot above the tail, as in the Irolo specimens.

All of the three specimens from Irolo have an irregular white patch at the base of the tail above, and one has a small irregular patch on the rump and another on the belly between the hind legs.

In the Irolo specimens the tail is less hairy and the hind feet more hairy than usual, and the hairs of the hind feet are white.

One of the eight specimens from Atlixco has the white spot at the base of the tail, though not so large as in the Irolo and Las Vigas specimens. The hind foot is scant haired in the Atlixco specimens, which peculiarity is probably seasonal, since the Atlixco specimens were collected in July, while those from Irolo were collected in March. The tails are less hairy than usual in the Irolo and Atlixco specimens.

Measurements (taken in flesh).—Average of 11 males from the south end of the Valley of Mexico and adjacent slopes (Amecameca, Tlalpam, Ajusco, Salazar, Huitzilac, and Lerma): Total length, 380; tail vertebræ, 112; hind foot, 50. Average of 7 females from same localities: Total length, 344; tail vertebræ, 105; hind foot, 46.

For cranial measurements see Table D, p. 210.

Specimens examined.—Total number 31, from the following localities: State of Mexico, Tlalpam, 4; Amecameca, 9; Ajusco, 2; Salazar, 1; Lerma, 1; State of Morelos, Huitzilac, 3; State of Hidalgo, Irolo, 3; State of Puebla, Atlixco, 8.

General remarks.—Mr. Nelson states that this large and powerful species is common in the south end of the Valley of Mexico, where it inhabits the soft soil of the bordering slopes and ranges on the west, south, and east sides of the southern two-thirds of the basin. Owing to the hard rock and clayey character of the middle and northern parts of the valley it does not occur there. On the west side it ranges up to the summit of the Sierra de Las Cruces (where he secured a specimen at an altitude of 11,000 feet near Salazar), and thence down the west slope into the border of the valley of Toluca, where a specimen was taken at Lerma. South of the Valley of Mexico it ranges up over the Sierra de Ajusco to an altitude of 10,000 feet, and across to Huitzilac on the south slope within the borders of the state of Morelos. On the east side of the valley it ascends the basal slopes of Mounts Popocatapetl and Iztaccihuatl. On the southeast slope of Popocatapetl it occurs at Tochimilco and on the adjacent plain about Atlixco, Puebla. It was also found at Irolo, Hidalgo, at the extreme north end of the Sierra

Nevada de Iztaccihuatl. Wherever found in agricultural land it is very destructive to corn, wheat, and other crops.

CRATOGEOMYS PEROTENSIS sp. nov.

(Pl. 8, fig. 6.)

Type from Cofre de Perote, Vera Cruz (altitude 9,500 feet). No. 54299 ♀ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected May 28, 1893, by E. W. Nelson. (Original No., 4889.)

Geographic distribution.—*Cratogeomys perotensis* inhabits the west and higher slopes of the Cofre de Perote, which are wooded, and probably descends to the northward to meet the range of *C. estor*. Mr. Nelson's specimens were obtained at the altitudes of 9,500 and 12,000 feet (map 4).

General characters.—Size rather large (smaller than *merriami* but larger than *estor*); no naked nose pad; hind feet and tail rather well haired.

Color.—Upper parts dark russet fulvous, everywhere finely mixed with black-tipped hairs; a small dusky patch behind each ear; an irregular white patch at base of tail in some specimens (in eight out of thirteen); under parts dark plumbeous, more or less washed with fulvous; hind feet usually dark proximally and white distally, but sometimes all white (and not always symmetrical on the two feet). Not one of the thirteen specimens is in the slaty-plumbeous pelage so common in *C. merriami*. This species has the tail more hairy than in the others of the *merriami* series, and in a number of specimens it is irregularly blotched with dusky and white, a peculiarity not observed in any other species.

Cranial characters.—Unfortunately the male of *perotensis* is unknown,* all of the thirteen specimens collected by Mr. Nelson on the Cofre de Perote being females. The skull of the female, however, furnishes excellent characters. It agrees with *merriami* in general form, in having the profile of the top of the skull a nearly straight line (not convex as in *fulvescens* and *castanops*) and in having a well developed sagittal crest. Whether or not the squamosals completely overlap the parietal in the adult male, as they do in *merriami*, is not known, but they probably do. Aside from its much smaller size, the skull of the ♀ *perotensis* may be distinguished at a glance from that of *merriami*, and from all other known species of *Cratogeomys*, by the slenderness of the jugal anteriorly. The jugal is not at all enlarged anteriorly, and is deeply mortised into the maxillary arm of the zygoma (see pl. 13, fig. 5).

*Unless one of the specimens obtained near Las Vigas (No. 54311) belongs to this species instead of *estor*. It is an immature male, too young to place the identity beyond question, but has the characters a young male *perotensis* would be expected to possess. The skull as a whole is larger than the adult female of *perotensis* (and hence considerably larger than *estor*); the rostrum and nasals are longer; the jugal is broader anteriorly, and the squamosals have already crept up over part of the parietals and would undoubtedly meet in advanced age.

In some instances the squamosal arm of the zygoma reaches so far forward and the maxillary arm so far backward that the two nearly meet above the jugal. The nasals end on or near the plane of the front of the zygoma, and the ascending branches of the premaxilla reach back past the plane of the lachrymals, thus leaving a long median projection of the frontal between the hinder ends of the premaxillaries. Skulls of *perotensis* may be distinguished from those of *estor* (from the lower northeast slopes of the same mountain) by larger size, much greater length of rostrum and nasals, slenderness of jugal anteriorly, greater length of sagittal crest, and by the form of the frontal between the orbits, which is broadly rounded instead of flat.

Measurements (taken in flesh).—Type: Total length 300; tail vertebræ 79; hind foot 40.

Average measurements of twelve females from type locality: Total length 310; tail vertebræ 88; hind foot 41.5.

For cranial measurements see Table D, p. 210.

Specimens examined.—Thirteen, all from Cofre de Perote, Vera Cruz.

CRATOGEOMYS ESTOR sp. nov.

(Pl. 8, figs. 4 and 5.)

Type from LAS VIGAS, VERA CRUZ (altitude 8,000 feet). No. 54308 ♂ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected June 12, 1893, by E. W. Nelson. (Original No. 5005.)

Geographic distribution.—The pine-covered hills and flats forming the extreme northeastern foothills of the Cofre de Perote, and also the belt of pine forest connecting the timber of the mountain with the wooded hills of the north. Its range is chiefly east and north of that of *perotensis*. *C. estor* thus reaches the extreme eastern edge of the table-land. Mr. Nelson's specimens were obtained at an altitude of about 8,000 feet (map 4, K).

General characters.—Size medium (smaller than *perotensis*); naked nasal pad small or absent; hind feet and tail rather well haired, as in *perotensis*.

Color.—Upper parts dark russet fulvous, everywhere finely mixed with black-tipped hairs; a small dusky patch behind each ear; an irregular white patch at base of tail above (on all ten specimens) and sometimes one below also; under parts dark plumbeous, more or less washed with fulvous; hairs of hind feet whitish, usually to ankle. Not one of the ten specimens is in the melanistic or slaty-plumbeous pelage so common in *merriami*.

Cranial characters.—Skull similar to that of *perotensis* in general form and profile, the top of the skull a nearly straight line—not strongly convex as in *fulvescens* and *castanops*. Contrasted with *perotensis* (the only species with which it requires comparison) *C. estor* differs in the following characters: Size smaller (♂ of *estor* about equaling ♀ of *perotensis*); rostrum much shorter; nasals shorter and broader ante-

riorly; jugal broader anteriorly and less deeply embeded between forks of maxillary arm of zygoma; frontal broader interorbitally on top of skull, and flat instead of broadly rounded; sagittal crest shorter anteriorly and perhaps not present in the female. The female with distant temporal impressions (No. 54306) figured on pl. 8, fig. 4, is not fully adult; in advanced age the sagittal area is probably nearly or quite obliterated by union of the temporal ridges.

Measurements (taken in flesh).—Type (♂ ad.): Total length 315; tail vertebræ 94; hind foot 41.

Average measurements of four males from type locality: Total length 313; tail vertebræ 89; hind foot 42.

Average measurements of four females from same place: Total length 277; tail vertebræ 75; hind foot 37.

For cranial measurements see Table D, p. 210.

Specimens examined.—Ten, all from Las Vigas, Vera Cruz.

General remarks.—*C. estor* resembles *C. perotensis* so closely in color and external characters that the two are practically indistinguishable except in size, *estor* being decidedly the smaller. In cranial characters, however, they are quite distinct, as pointed out above.

Mr. Nelson states that wherever the pine forests are cleared away and the ground cultivated within the range of this species, the animal multiplies rapidly and becomes exceedingly destructive to crops.

CRATOGEOMYS OREOCETES sp. nov.

(Pl. 8, figs. 1 and 2.)

Type from MOUNT POPOCATAPETL, MEXICO (altitude, 11,000 feet). No. 57963 ♀ yg. ad. U. S. National Museum, Department of Agriculture collection. Collected January 7, 1894, by E. W. Nelson and E. A. Goldman. (Original No. 47.)

Geographic distribution.—The boreal higher slopes of Mount Popocatapetl, above the range of *Cratogeomys merriami* (above 11,000 feet altitude.)

General characters.—Incisor sulcus broadly open and wholly on inner side; size rather large; pelage soft; nasal pad small; hind feet and tail sparsely haired.

Color (of type specimen).—Dusky, darkest on head and along median part of back; tips of hairs washed with pale brown; a golden brown patch under each eye; forefeet dusky; hind feet white. Apparently the specimen is just beginning the change from the plumbeous to the brown pelage.

Cranial characters.—Zygomatic arches narrow, their sides nearly parallel; anterior angle moderately expanded (about as in *Heterogeomys hispidus*); temporal ridges strongly developed; nasals wedge-shaped, not inflated anteriorly, ending posteriorly in front of plane of anterior face of zygoma; ascending branches of premaxilla just reaching plane of orbit, not divaricating behind nasals; frontal flat (orbital edge rounded), rather broad interorbitally and posteriorly, reaching forward

between premaxillæ much further than laterally; supraorbital prominences not strongly developed; temporal ridges anterior to interparietal straight, inclosing an elongated wedge-shaped interspace (but very different from the interspace between the strongly curved ridges of *H. hispidus*); interparietal elongated antero-posteriorly, very much longer than broad; jugal long and large, forming an important part of arch; lambdoid crest strongly and evenly convex posteriorly; occipital plane flat, sloping slightly forward from below upward; posterior ends of palatals excavated laterally; pterygoids narrow lingulæ with parallel sides, as in *C. merriami;* audital bullæ relatively short and swollen, more subglobular than in *H. hispidus;* brain case rising abruptly from posterior roots of zygomata, much as in *hispidus* (not flatly rounded as in the *merriami* group and in *peregrinus*). Under jaw short and rather narrow, as in *hispidus;* angular processes short.

Dental characters.—Face of upper incisors unisulcate, the groove wholly on inner side and broadly open, as in *merriami*—not narrow and deep as in *H. hispidus* and *M. heterodus;* breadth of enamel face of upper incisor slightly greater than antero-posterior diameter of tooth; outer side of tooth strongly beveled immediately behind enamel, as in the lower incisor of *merriami.* Lower incisor narrow, the transverse diameter less than the antero-posterior. Crown of last upper molar much broader than long; no distinct heel; the inner side convex, the outer side emarginate and longer. The curvature of the prism of this tooth is much less than in the *merriami* series and less than in *H. hispidus.*

The premolar is the longest tooth and is slightly convex anteriorly; m^1 and m^2 are hardly shorter and are subequal (or m^2 may be slightly the shorter); both are strongly convex anteriorly; m^3 is more than two-thirds the length of m^2 and is only moderately convex anteriorly.

Measurements (taken in flesh).—Type specimen: Total length, 318; tail vertebræ, 92; hind foot, 43.

For cranial measurements see Table D, p. 211.

General remarks.—*Cretogeomys oreocetes* does not require close comparison with any known species. From its nearest neighbor of the lower slopes of the same mountain (*C. merriami*) it differs conspicuously in smaller size, narrower zygomata, shorter and more globular audital bullæ, and in the presence of strongly developed temporal ridges.

From *C. peregrinus*, which inhabits the corresponding boreal slopes of the neighboring mountain, the lofty Iztaccihuatl, it may be distinguished by its narrower and higher cranium, by the beveled outer face of the upper incisor, the convex (instead of notched) inner border of crown of last upper molar, and other characters mentioned under that species.

The measurements of the skull of *C. oreocetes* (see table D) show that the posterior breadth of the cranium is nearly equal to the zygomatic breadth. This is due to the narrowness of the zygomatic arches—not to any unusual breadth of the cranium posteriorly.

CRATOGEOMYS PEREGRINUS sp. nov.

(Pl. 8, fig. 3.)

Type from MOUNT IZTACCIHUATL, MEXICO (altitude 11,500 feet). No. 57964 ♀ old. U. S. National Museum, Department of Agriculture collection. Collected January 9, 1894, by E. W. Nelson and E. A. Goldman. (Original No. 50.)

Geographic distribution.—The boreal higher slopes of Mount Iztaccihuatl, above the range of *Cratogeomys merriami* (above 11,500 feet altitude).

General characters.—Size medium or rather large; hind foot and tail scant haired; nasal pad small; forefoot large (with claws nearly equaling hind foot with claws). Color peculiar.

Color (of type and only specimen).—Steel gray from the intimate admixture of dusky and whitish hairs; under parts paler than upper; throat, sides of face, and fore feet darker. The hairs of the hind foot are whitish; of the tail dusky.

Cranial characters.—The skull of the type, a very old female, has the posterior part of the cranium very flat and broad, and the zygomata broad and bowed outward, suggesting *Platygeomys fumosus.* In other respects the resemblances are more in the direction of *Cratogeomys merriami*, with a few characters pointing toward *Heterogeomys.* The zygomatic arches are widely spreading, not divergent anteriorly but broadest across the middle (breadth anteriorly slightly less than greatest breadth of squamosals posteriorly); the anterior roots stand out at nearly a right angle; the antero-external angle is moderately expanded and sharply angular when seen from the side; rounded as seen from above. The jugal is rather large and forms an important part of the arch as in *C. merriami.* The muzzle and nasals are short, the latter broad anteriorly and truncated posteriorly about on the plane of the anterior face of the zygomata. The ascending branches of the premaxilla are broad and blunt posteriorly, barely reach the plane of the orbits, and do not approximate or divaricate behind the nasals. The frontal reaches furthest forward along the median line; the suture at base of maxillary root of zygoma (on top of skull) is nearly a straight line. There is no sagittal crest, but the temporal ridges approximate immediately in front of the interparietal, from which point they divaricate in both directions; anteriorly they slope slightly outward in nearly a straight line to a point about opposite the posterior part of the postorbital prominences of the frontal where they become less distinct and curve abruptly outward. The interspace is an elongated wedge, as in *C. oreocetes*, and is not depressed below the level of the temporal ridges, a result perhaps of the extreme age of the animal. In shape it differs widely from that of the genus *Heterogeomys.* The great breadth of the cranium posteriorly is due to lateral expansion of the squamosals, as in *Platygeomys.* The greatest breadth across squamosals (over mastoids) is slightly greater than the zygomatic breadth anteriorly. The interparietal is not covered by the parietals and is

elongated antero-posteriorly. The plane of the occiput is moderately smooth and slopes forward; it is low and broad, the breadth being about two-and-a-half times the height. The mastoid bullæ are much as in *merriami*, except that the inferior border is shorter and the inner side is armed with a short blunt spine projecting inward and slightly backward. (This may be abnormal, but the points are symmetrical on the two sides.) The audital bullæ are rather short and tumid (much as in *oreocetes*) and the anterior projection which abuts against the basisphenoid is sharply set off by a deep notch on the upper side. The palatopterygoids are lingulate, slightly broader than in *merriami*, the sides nearly parallel; mandible short and narrow, resembling that of *oreocetes*, from which it differs in having the angular processes even shorter and the coronoids more hooked.

Dental characters.—Upper incisors with a single very broad and open groove (broader even than in *oreocetes*), its deepest point on the inner side of the median line; breadth of enamel face greater than antero-posterior diameter of tooth. Lower incisors narrow, the breadth of the enamel face being considerably less than the antero-posterior diameter of tooth. Crown of last upper molar not distinctly heeled, its inner border about half the length of outer and deeply notched; outer side broadly concave.

Measurements (taken in flesh).—Type specimen: Total length, 304; tail vertebræ, 87; hind foot, 42.

For cranial measurements see Table D, p. 211.

CRATOGEOMYS CASTANOPS (Baird).

(Pl. 12, fig. 1; pl. 13, fig. 17; pl. 14, fig. 6.)

Pseudostoma castanops Baird, Report Stansbury's Exp'd. to Great Salt Lake, June 1852, 313. (Type from near Bents Fort, Colorado.)

Geomys castanops Baird, Mammals of North America, 1857, 381–386.

Geomys clarkii Baird, Proc. Acad. Nat. Sci., Phila., VII, 1855, 332. (Type from Presidio Del Norte, on the Rio Grande, Chihuahua, Mexico.)

Type locality: "Prairie road to Bents Fort," near the present town of LAS ANIMAS, COLORADO, on the Arkansas River. (Type in U. S. National Museum.)

Geographic distribution.—Isolated areas on the Great Plains from the Arkansas River in Colorado, southward through eastern New Mexico (west to Albuquerque), and western Texas to Santa Rosalia, Chihuahua, and Jaral, Coahuila (map 4, II).

General characters.—Size, medium; coloration, yellowish-brown; tail of medium length; rather scant haired.

Color.—Upper parts yellowish brown or buffy ochraceous tinged with yellowish, more or less mixed with black-tipped hairs, which are much more numerous in winter pelage; under parts buffy.

Cranial characters.—Skull very broad and heavy; zygomatic arches widely spreading anteriorly and strongly decurved; profile of skull convex on top; end of maxillary root of zygoma greatly expanded,

forming a broad plate, into which the enlarged head of the jugal is received; *sides of basioccipital parallel. C. castanops* differs from *C. fulvescens* in having the basioccipital narrow, its sides excavated and parallel; the nasals and nasal branches of the premaxilla more produced posteriorly; the latter cutting the plane of the orbits, and in lacking the thickened sockets of the upper incisors.

Measurements (taken in flesh.)—An adult male from Las Animas, Colorado (practically type locality): Total length, 295; tail vertebræ, 95; hind foot, 37.

Average of 3 females from same locality: Total length, 256; tail vertebræ, 77; hind foot, 33.

For cranial measurements see Table D, p. 211.

Specimens examined.—Total number 43, from the following localities: Olney, Colorado, 2; Las Animas, Colorado (type locality), 6; Chico Springs, New Mexico, 2; Albuquerque, New Mexico, 3; Eddy, New Mexico, 3; Sierra Blanca, Texas, 1; Marfa, Texas, 3; Eagle Pass, Texas, 13; Samalayuca, Chihuahua, Mexico, 2; Gallego, Chihuahua, Mexico, 2; Santa Rosalia, Chihuahua, Mexico, 4; and Jaral, Coahuila, Mexico, 5.

General remarks.—Coues has already shown that *clarkii* can not be distinguished from *castanops*, and the examination of a much larger series than heretofore available confirms this determination. The peculiar line of demarkation in the type specimen* described by Baird as separating the color of the head and neck from that of the rest of the upper parts, is now well known as the molt line (which progresses from before backward); and the alleged differences in the feet and skull donot hold good in the ample series (forty-three specimens) now at hand. The species presents considerable geographic variation in size (mostly sporadic), as usual in members of the family having an extensive range. The only notable departure from the type observed in the present series is in two specimens from Chico Springs, N. Mex. These specimens are smaller than the type form, brighter and more 'yellowish-chestnut' in color, and the fore feet, hind feet, and tail are distinctly blackish. The tail furthermore is well covered with hair for its entire length.

Mr. Vernon Bailey tells me that *Cratogeomys castanops* is a very injurious species to orchards and nurseries. Along Onion Creek, 30 miles southwest of Marfa, in Presidio County, Texas, he found them eating the roots of fruit trees where "two or three soon spoil an orchard if left in it; the owners did not know how to get rid of them."

CRATOGEOMYS CASTANOPS GOLDMANI subsp. nov.

Type from CAÑITAS, ZACATECAS, MEXICO. No. 57965 ♀ yg. ad. U. S. National Museum, Department of Agriculture collection. Collected December 24, 1893, by E. A. Goldman. (Original No. 286.)

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* The type specimen, formerly in the Patent Office, is now in the National Museum, but is in very poor condition, having been exposed to the light for nearly forty years, as a result of which it is so faded that no trace of the original color remains.

General characters.—Similar to *C. castanops* in size and external appearance, but differing in cranial characters. Tail and hind feet rather well haired for a Pocket Gopher.

Color.—Upper parts dull buffy-ochraceous, moderately mixed with black-tipped hairs; under parts paler.

Cranial characters.—Unfortunately all of the five specimens at hand of this form are females. Compared with females of *C. castanops* the skulls differ in being broader, shorter, and flatter, with less decurved zygomata, and decidedly shorter and broader nasal bones. The shortening is chiefly in the rostrum; the broadening chiefly in the brain case. The basioccipital averages longer and somewhat larger and its sides are less truly parallel, being a little broader posteriorly than anteriorly. The plane of the occiput is narrow and much elongated transversely. The coronoid process of the mandible is long, depressed, and reaches far back.

Measurements (taken in flesh).—Type: Total length, 270; tail vertebræ, 90; hind foot, 35.

Average measurements of three females from type locality: Total length, 257; tail vertebræ, 83; hind foot, 34.3.

For cranial measurements see Table D, p. 211.

Specimens examined.—Total number 5, all from Cañitas, Zacatecas.

CRATOGEOMYS FULVESCENS sp. nov.

(Pl. 12, fig. 2.)

Type from CHALCHICOMULA, STATE OF PUEBLA, MEXICO. No. 58168 ♂ ad. U. S. National Museum, Department of Agriculture collection. Collected January 15, 1894, by E. W. Nelson and E. A. Goldman. (Original No. 5651.)

Geographic distribution.—The basin-like plain of eastern Puebla, Mexico, from Esperanza north to Perote and west to the northeast base of Mount Malinche in Tlaxcala (map 4, J).

General characters.—Upper incisors unisulcate; forefeet shorter than hind feet. Similar in general appearance to *C. castanops*, but larger; color darker; tail rather longer, darker, and slightly more hairy.

Color.—Upper parts grizzled yellowish-brown, liberally mixed with dark-tipped hairs; under parts buffy-fulvous or ochraceous-buff. Compared with *castanops* the general color is darker, owing to more bountiful admixture of dark-tipped hairs.

Cranial characters.—Skull rather massive; zygomata squarely spreading, angles broadly expanded; alveoli of upper incisors thickened; profile of top of skull very convex; rostrum decurved anteriorly.

The fronto-maxillary suture is peculiar, its anterior end usually reaching or nearly reaching the plane of the front of the zygoma—in all the allied species the frontal ends about opposite the middle of the anterior root of the zygoma.

The height of the roof of the cranium above the palate, and of the brain case above the posterior roots of the zygomata, are much greater than in any other member of the genus, and the breadth of the skull posteriorly is much less.

Contrasted with *C. castanops* the skull of *fulvescens* differs in the following particulars: size larger; rostrum broader; sockets of upper incisors thicker, bulging externally; nasals and ascending branches of premaxilla shorter posteriorly, the former hardly reaching plane of front of zygoma, the latter not reaching plane of orbits; basioccipital much broader and wedge-shaped, as usual in the genus (in *castanops* the basioccipital is narrower and its sides are parallel, see pl. 12, figs. 1[a] and 2[a]).

Measurements (taken in flesh).—Type specimen (♂): Total length, 318; tail vertebræ, 102; hind foot, 43.5.

Average of three males from type locality: Total length, 327; tail vertebræ, 105; hind foot, 43.

Average of six females from type locality: Total length, 302; tail vertebræ, 97; hind foot, 39.6.

For cranial measurements see Table D, p. 211.

Specimens examined.—Total number 11, from the following localities: Chalchicomula, Puebla, 9; Perote, Vera Cruz, 2.

General remarks.—*C. fulvescens* does not require close comparison with any known species except *C. castanops*, which it resembles in the grizzled yellowish-brown color of its upper parts. It is more fulvous than *castanops*, from which it differs further in larger size and in the cranial characters above pointed out. Specimens from Perote are more yellowish and less fulvous than those from Chalchicomula.

Mr. Nelson states that this species inhabits the sandy open plain from an altitude of 8,000 feet in the lower parts of the basin up to 9,000 feet on the west slope of Mount Orizaba. He states further: "In this district its range is almost identical with that of *Dipodomys phillipsi*. Like the latter species it follows up the cultivated land into the lower border of the pine forest on Mount Orizaba, and is common also about the northeast base of Mount Malinche. These gophers are particularly numerous in cultivated ground, and are very destructive to corn and grain of all kinds."

Genus PLATYGEOMYS * nob.

(Pl. 3; pl. 10, fig. 8; pl. 13, figs. 1–3; pl. 14, fig. 9; pl. 15, fig. 7; pl. 17, fig. 4; pl. 18, fig. 5; pl. 19, fig. 7.)

Type Geomys gymnurus Merriam, from ZAPOTLAN, JALISCO, MEXICO.

Dental characters.—Upper premolar with three enamel plates (the posterior absent), its shaft nearly straight. First and second upper molars with one enamel plate each (posterior absent).

* *Platygeomys*, from πλατύς, broad, wide, + *Geomys*, with reference to the great breadth of the cranium.

Third upper molar an incomplete double prism, the outer side abruptly narrowed behind the anterior prism; axis of heel antero-posterior; inner enamel plate normally less than two-thirds as long as anterior plate; not covering posterior face of tooth; outer plate normally as long as inner and usually reaching posterior edge of heel.

Upper incisor strongly *unisulcate*, the sulcus median or slightly on inner side (fig. 21[2]).

Cranial characters.—Skull large, heavy, and flat; hinder part of cranium extraordinarily broad and flat, the great breadth due chiefly to lateral expansion of the squamosals, which not only project as a thin shelf beyond the brain case, increasing the size of the glenoid fossa both anteriorly and posteriorly, but also completely arch over and conceal the postglenoid notch, curving with only a shallow concavity from the posterior angle of the zygomatic arch to and beyond the extreme tip of the transversely elongated mastoid; zygomatic arches massive, broadly spreading anteriorly, the antero-external angle expanded vertically into a triangular plate between the strongly produced and decurved external angle and the evenly rounded orbit (the resulting plate made up in part of the distal end of the maxillary arm of the arch, and in part of the anterior end of the jugal, which is usually expanded); jugal normally large and broad, forming an important part of the arch; pterygoids vertical lamellæ with inferior border everted; orbitosphenoids larger than in *Cratogeomys* but not normally articulating with alisphenoid; mesethmoid a little more than a half crescent, its anterior border strongly rounded above (pl. 18, fig. 5); endoturbinals together forming an elongated oblique plate which is sharply pointed antero-superiorly, owing to the elongation of the upper endoturbinals (pl. 19, fig. 7); no extension of os planum in front of lower endoturbinals and no curving down of vomerine edge of os planum below plane of roof of narial passage; floccular fossa ill defined and not separated from internal auditory meatus by a distinct ridge; ridge separating superior from inner surface of petrous only feebly developed (pl. 17, fig. 4; and pl. 18, fig. 5).

In addition to the above-described generic characters, most of which are in strong contrast to those of *Cratogeomys*, the following points are selected with special reference to antithesis with *Cratogeomys* (which see): Breadth of cranium posteriorly (above mastoids) equal to or greater than greatest zygomatic breadth; breadth of occipital plane at least two and a half times its height; lambdoid crest sinuous, presenting three posterior concavities; squamosal expansion chiefly away from median line—not covering inner part of parietals; mandible very much broader than long* (including incisors); angular processes of mandible

* The extraordinary breadth of the mandible across the angular processes is not due alone to the great length of these processes, but in part to their position. They are higher and more nearly on a level with the incisor protuberance than in any other form, and the jaw as a whole is flatter.

extraordinarily long and spreading, reaching out so far laterally that the knob over root of incisor is midway between condyle and end of angular process (pl. 3); squamosal arm of zygoma covering about half (in *fumosus* more than half) of upper edge of jugal, which latter enters broadly into formation of zygomatic arch; free part of upper edge of jugal equal to length of basioccipital on median line (except in *fumosus*); paroccipital processes large and expanded, forming recurved flanges; incisors slender in contrast to those of the *merriami* series; antero-posterior and transverse diameters of incisors subequal; enamel face of lower incisors forming an inconspicuous bead on outer side of tooth, behind which the tooth is not beveled, the transverse diameter through the enamel face being inappreciably greater than posteriorly.

KEY TO SPECIES OF PLATYGEOMYS.

1[a] *Zygomatic arches parallel or bowed outward in the middle* .... *fumosus.*
1[b] *Zygomatic arches strongly divergent anteriorly*:
  Jugal only slightly expanded anteriory .... *planiceps.*
  Jugal broadly expanded anteriorly:
    Nasals strongly wedge-shaped; narrow posteriorly; reaching plane of zygoma .... *gymnurus.*
    Nasals not wedge-shaped; broad posteriorly; not reaching plane ot zygoma .... *tylorhinus.*

PLATYGEOMYS GYMNURUS Merriam.

(Pl. 3; pl. 10, fig. 8; pl. 13, fig. 2; pl. 15, fig. 7; pl. 17, fig. 4; pl. 18, fig. 5; pl. 19, fig. 7.)

Geomys gymnurus Merriam, Proc. Biol. Soc. Washington, VII, Sept. 29, 1892, 166-167.

Type locality.—ZAPOTLAN, JALISCO, MEXICO. (Type in U. S. National Museum.)

Geographic distribution.—Valley of Zapotlan and adjacent slopes of the Sierra Nevada de Colima, Jalisco, and the volcano of Colima down to the upper edge of the plain of Colima, Mexico.

General characters.—Size very large; a naked pad on end of nose; tail naked; feet sparsely haired; hinder part of cranium extraordinarily broad.

Color.—Upper parts dark reddish-brown or chestnut, varying to sooty plumbeous or slate-black, slightly paler below. The rusty specimens have a dusky patch about each ear and a larger one on the nose. The depth of the chestnut seems to increase with the age of the hair, specimens in the molt having the new hair very dark and only washed on the tips with chestnut. The hairs of the hind feet are scattered and nearly colorless. The young are glossy slate-black, with the sides and rump conspicuously sprinkled with whitish bristles.

Cranial characters.—The skull of *Platygeomys gymnurus* differs from all others of the family (except the related *P. tylorhinus* and *planiceps* here described) in the extraordinary breadth and flatness of the hinder part of the brain case, the result of lateral expansion of the squa-

mosals, which completely arch over and conceal the postglenoid notch, curving with a shallow concavity from the posterior angle of the zygomatic arch to the extreme tips of the transverely elongated mastoids, which they overreach. The breadth of the cranium here equals or exceeds the greatest zygomatic breadth. Correlated with this unprecedented breadth of the posterior part of the cranium is an even more extreme lateral extension of the angular processes of the mandible. The zygomatic arches are widely spreading anteriorly, with broadly expanded subtriangular outer angles. The jugals are large, broadly expanded anteriorly, enter largely into the outer wall of the orbital fossa, and, as a rule, terminate anteriorly in a straight edge, which articulates with the lower third of the ascending or maxillary arm of the zygoma without being mortised into it as usual in the group; still the front of the jugal rests on a strong shelf of the maxillary arm, and is commonly overtopped by a short spicule. The exposed part of the upper edge of the jugal forming part of the outer wall of the orbital fossa is usually, though not always, as long as the basioccipital (on median line), and as a rule the posterior half of the jugal is overlapped by the squamosal arm of the zygoma. The fronto-maxillary suture is straight or slightly convex outward, while its continuation as the premaxillo-maxillary suture (on top of the skull) is strongly concave inward, the result being that the suture at the base of the maxillary arm of the zygoma, taken as a whole, is shaped like the letter S somewhat drawn out. In *tylorhinus* and *planiceps* it is broadly and uniformly convex inward. The nasals end posteriorly on or a little behind the anterior plane of the zygoma, and are strongly wedge-shaped and much narrower posteriorly than in *tylorhinus*. The nasal branches of the premaxilla may or may not reach the plane of the orbits; they approximate slightly behind the nasals.

The occipital plane is exceedingly broken and irregular; the lambdoid crest overhangs it as a sinuous ledge throughout its entire length; the greatly enlarged paroccipital processes stand out like broad flanges from the exoccipitals, projecting strongly outward and backward, forming, in conjunction with the middle part of the lambdoid crest, a remarkable basin-shaped inclosure, outside of which, and far anterior to the great paroccipital flanges, are the transversely-elongated mastoids (pl. 15, fig. 7). In striking contrast is the smoothly planed-off occiput of *Heterogeomys hispidus* (pl. 15, fig. 4).

The shape of the lambdoid crest is peculiar; it is deeply sinuous, with three concavities directed forward (of which the median is deep, the lateral shallow), and two strong convexities directed backward; at each end it terminates in a club-shaped knob directed outward. Looking at the skull from above there is nothing to indicate the limits of the brain case, the broad squamosals being convex upward behind the zygomata, without trace of the lateral depression that marks off the brain case in *Cratogeomys* and most other members of the family.

Measurements (taken in flesh).—Average of three males from type locality (Zapotlan, Mexico): Total length, 352.6; tail vertebræ, 105.3; hind foot, 53.3. Average of three females from same place: Total length, 341; tail vertebræ, 91; hind foot, 49.6.

For cranial measurements see Table E, p. 212.

Specimens examined.—Total number, 10, from the following localities in Jalisco, Mexico: Zapotlan, 7; Sierra Nevada de Colima, 3.

General remarks.—*Platygeomys gymnurus* may be regarded as the type (for it is the largest and most extreme in cranial peculiarities) of a remarkable series of Pocket Gophers inhabiting southern Mexico from the Sierra Nevada de Colima of Jalisco eastward to the north slope of the Volcan Toluca in the State of Mexico, and Tula in Hidalgo. Externally these animals differ so little from the larger species of *Cratogeomys* as to be distinguished with difficulty, but in cranial characters they may be told at a glance. The number of recognizable forms now known is four, of which one (*fumosus*) is very distinct from the others; the remaining three are closely related (*gymnurus*, *tylorhinus*, and *planiceps*) and two of them (*tylorhinus* and *planiceps*) may be found to intergrade when specimens are obtained from intermediate localities along the line of their distribution, in which event the latter must be reduced to subspecific rank. Still another form that might be deemed worthy of separation is the Patzcuaro animal mentioned under the head of *P. tylorhinus.*

All the members of the *gymnurus* series have the upper parts more or less plentifully sprinkled with long, slender, bristle-like hairs which protrude far beyond the ordinary fur. In *fumosus* these hairs are very conspicuous, owing to the marked contrast of their whitish color with the blackish-slate of the body; the same is true of the young in *gymnurus*, but in the adult they harmonize so well with the prevailing reddish-brown or chestnut tints that they may be easily overlooked. They are most abundant in the Patzcuaro specimens of *tylorhinus.*

Mr. Nelson states that the range of *Platygeomys gymnurus*, so far as determined by him, is limited to the valley of Zapotlan and slopes of the Sierra Nevada de Colima and base of the adjacent volcano of Colima, and the immediate vicinity. On the north slope of the Sierra Nevada de Colima he found them up to an altitude of 11,000 feet, among the firs and alders, where a specimen was secured. Thence to the base of the mountain they are rather common on open grassy slopes, and range out over all of the adjacent valley of Zapotlan. In this latter district they were usually found in fields, where they do much damage to corn and wheat. Zapotlan Valley has an altitude of about 4,500 feet, and is an open basin-like plain just below the pines and oaks of the mountains. On the extreme upper border of the plain of Colima, near the southwest base of the volcano, at an altitude of about 3,500 feet, he saw numerous diggings of a gopher, which was probably this species.

PLATYGEOMYS TYLORHINUS sp. nov.

(Pl. 13, fig. 1.)

Type from TULA, HIDALGO, MEXICO. No. 51883 ♂ ad. U. S. National Museum, Department of Agriculture collection. Collected March 13, 1893, by E. W. Nelson. (Original No. 4442.)

Geographic distribution.—Tula, Hidalgo, and thence southwesterly along the north slope of the Sierra Madre to the vicinity of Patzcuaro, Michoacan.

General characters.—Size, large; tail nearly naked; a naked pad on end of nose; coloration dark. Similar to *P. gymnurus*, but smaller, with shorter and more hairy hind feet, which are distinctly white in contrast to dark of ankles and legs; skull remarkably broad and flat, as in *P. gymnurus*, but lighter and differing further in important characters.

Color.—Upper parts chestnut or liver-brown, as in *Geomys bursarius;* under parts similar but slightly paler, the plumbeous showing through in places; legs and ankles concolor with body; hind feet white in contrast.

Cranial characters.—Skulls of *P. tylorhinus* differ from those of *P. gymnurus* in smaller size, narrower rostrum, and shorter nasals, which do not reach plane of zygomatic arches. The most conspicuous difference is in the shape of the nasals: instead of being wedge-shaped, as in *gymnurus*, they are much broader posteriorly and abruptly truncated behind, and the premaxillæ do not approximate behind them. The skull as a whole is much less massive and the maxillary arm of the zygoma less thickened than in *gymnurus*. The jugal is enlarged throughout and expanded anteriorly into a broad plate which abuts against the sides of the maxillary part of the zygomatic arch, which latter is hardly excavated to receive it, sending out a small shelf below and a short spicule above, much as in *gymnurus*. The suture at the base of maxillary root of zygoma is broadly convex inward; in *gymnurus* it is shaped like a drawn-out S. As usual, the skull of the female is much smaller than that of the male, and the jugal is narrower.

Measurements (taken in flesh).—Type specimen, ♂ ad.: Total length, 345; tail vertebræ, 100; hind foot, 45. Average of two ♀ specimens from type locality: Total length, 298; tail vertebræ, 91.5; hind foot, 39.5.

For cranial measurements see Table E, p. 212.

Specimens examined.—Total number 9, from the following localities in Mexico: Tula, in Hidalgo, 4; Patzcuaro, in Michoacan, 5.

General remarks.—Specimens from Patzcuaro, State of Michoacan, are intermediate in size and form of nasals between *gymnurus* and typical *tylorhinus* from Tula, but exceed the latter in the expansion of the jugal and whiteness of the hind feet. The hind feet are more hairy, and the ankles are dark plumbeous instead of chestnut, causing the white to stand out in stronger contrast. Skulls of the Patzcuaro

animal differ further from those from Tula in having smaller and shorter pterygoid lamellæ (as seen from the side), leaving more space between their posterior edge and the audital bullæ. The posterior ends of the palatals are smaller, thicker, and have the outer edge straighter. In the Tula skulls the palatals are thinner and broader, with the outer edge irregularly sinuous. In the Patzcuaro animal the jugals are conspicuously broader anteriorly than in those from Tula, but as in the latter they are much less expanded in the female than in the male.

There is an average difference in external characters by which the Patzcuaro specimens may be distinguished from specimens from Tula and the Volcano of Toluca. They are darker and richer in color (the chestnut being more ferruginous), and the head is mainly slate-black, more or less faintly washed with rusty. This color does not cover the head uniformly but is disposed in a tolerably regular pattern from which there is little variation in the series of specimens at hand. The slate-black covers the muzzle, reaching back along the median line as far as the plane of the eyes, and sends a broad arm backward on each side to the shoulders, inclosing the eye and ear. The chestnut of the back comes forward over the top of the head to about the plane of the eyes, and on the sides of the face below the eyes to and sometimes including the cheeks. Possibly there is something seasonal in this pelage; all of the Patzcuaro specimens were collected at the same time—the latter half of July.

Mr. Nelson contributes the following information respecting the local distribution of *P. tylorhinus:* "I found this species common along the north slope of the mountains about Lake Patzcuaro and thence to the vicinity of Lake Cuitzeo, in Michoacan. All of this district lies in the zone immediately below the pines (from about 5,500 to 6,800 feet altitude), and is largely cultivated to wheat and corn. The gophers are particularly numerous in the fields, where they do considerable damage to crops. They range up into the lower border of the forest where *Zygogeomys trichopus* is found. Beyond Lake Cuitzeo no work was done to the northeast until Tula, Hidalgo, was reached. There these animals were found in small numbers at an altitude of about 6,000 feet, in the vicinity of the town. They were only noted about the borders of small basin-like sinks, where the land was under cultivation. Not being numerous here their depredations in the grainfields were of little moment. The district from Lake Cuitzeo to Patzcuaro has a cool climate, with abundant rains during the summer months. Tula lies in a much more arid and warmer zone."

PLATYGEOMYS PLANICEPS sp. nov.

(Pl. 13, fig. 3; pl. 14, fig. 9.)

?*Ascomys mexicanus*, Licht., Brants Muizen, 1827, 27-31 (in part).

Type from north slope VOLCAN TOLUCA, MEXICO. No. 55906 ♂ U. S. National Museum, Department of Agriculture, collection. Collected September 12, 1893, by E. W. Nelson. (Original No. 5466.)

Geographic distribution.—Northern and eastern slopes of the volcano of Toluca and adjacent part of the valley to the city of Toluca, from an altitude of 8,600 feet up to the vicinity of timber line.

General characters.—Similar to *P. tylorhinus*, from which it differs inappreciably in external appearance except in the greater length of the tail. Upper incisors unisulcate; skull broad and flat; size large; tail nearly naked; a naked pad on end of nose; forefeet with claws shorter than hind.

Color.—Upper parts chestnut, as in *tylorhinus* from Tula; under parts similar but paler, the plumbeous basal fur showing through in places; legs and ankles concolor with body; hairs of hind feet whitish, but scant. Nose below eyes blackish; a large blackish spot around each ear. One specimen is dark plumbeous, washed with chestnut, and has the head markings described under the Patzcuaro specimens of *tylorhinus.*

Cranial characters.—Skull similar to that of *tylorhinus*, from which it differs chiefly in the form of the jugal bone, which is narrow throughout or very slightly expanded anteriorly—not broadly expanded as in *tylorhinus.* It differs further from *tylorhinus* in having the nasals less squarely truncate posteriorly (and ending about on plane of middle of maxillary root of zygoma); the ascending branches of premaxilla rounded posteriorly and ending near anterior plane of orbits—not passing nasals so far as in *tylorhinus;* the cranium very broad and flat; occipital plane more than two and a half times as broad as high. The rostrum is narrow, but not narrower than in some specimens of *tylorhinus* from Tula.

Measurements (taken in flesh).—Type specimen ♂ : Total length, 372; tail vertebræ, 121; hind foot, 46. Average of two females from type locality: Total length, 336.5; tail vertebræ, 100; hind foot, 43.

For cranial measurements see Table E, p. 212.

Specimens examined.—Three, all from the north slope of the Volcan de Toluca, State of Mexico.

General remarks.—This animal may prove to intergrade with *tylorhinus* of Tula, in which case it must be reduced to subspecific rank. The number of specimens at hand (only three) is not sufficient to determine the constancy of the characters that distinguish it from *tylorhinus.* The chief differences, as above stated, are the longer tail and narrower jugal. The jugal is always narrower in females than in males, and two of the three specimens are females. The male (type specimen), while full grown, is not old, and its jugal may be abnormally slender, though there is nothing about the skull to suggest this belief. In the light of the present material no course seems open but to recognize the animal as a distinct species. It may be remarked, however, that it is the poorest species described in the present paper.

Respecting its local distribution Mr. Nelson states: "On the slopes of the Volcano of Toluca this species is not very numerous, but is found

scattered in small numbers continuously from the base of the mountain up to the vicinity of timber line, usually in open parts of the pine forest and in small grassy parks. It is more common in the valley of Toluca, where it inhabits fields and grassy meadows and is very destructive to crops."

PLATYGEOMYS FUMOSUS Merriam.

(Pl. 11, fig. 4, and pl. 14, fig. 8.)

Geomys fumosus Merriam, Proc. Biol. Soc. Washington, VII, September 29, 1892, 165-166

Type locality.—COLIMA CITY, MEXICO. (Type in U. S. National Museum.)

Geographic distribution.—Plain of Colima, Mexico. (Altitude 1,500 to 2,000 feet.)

General characters.—Size medium, about equalling *Geomys bursarius* (smaller than the other species of *Platygeomys*); pelage rather soft, sparingly mixed with long whitish bristles, which are most abundant on the rump; tail and hind feet nearly naked; nasal pad not strongly developed; color very dark.

Color.—Upper parts everywhere plumbeous slate or dark sooty-brown, faintly washed in places, particularly along the sides, with pale reddish-brown; color of upper parts fading in worn pelage to pale dull liver brown, usually in irregular patches; underparts scant haired, pale plumbeous, sometimes indistinctly washed with pale brownish. A young specimen, about half grown (No. 34186 ♂), is rich slate black above, conspicuously lined with whitish bristly hairs, which are most abundant on the rump, and more so on the sides than along the middle of the back. There is also a faint brownish tinge on the sides of the neck. The scant hairs of the belly are very pale plumbeous or even soiled whitish.

Cranial characters.—Skulls of *Platygeomys fumosus* agree with those of the other members of the *gymnurus* group in the extreme breadth of the hinder part of the cranium, due to the expansion of the squamosals beyond the parieties of the brain case, and in the great lateral production of the angle of the mandible. *P. fumosus* departs from the *gymnurus* series markedly in the form of the zygomatic arches, which, when looked at from above, are rounded instead of sharply angular anteriorly, and have the sides nearly parallel or bowed outward, so that they are broadest across the middle instead of anteriorly. In *gymnurus* they are usually widely divergent anteriorly. *P. fumosus* differs further from the other members of the *gymnurus* series in greater interorbital breadth of frontals; strongly wedge-shaped nasals; more elongated postpalatal pits (which reach the plane of front of last molars), and in having the anterior end of jugal more deeply embedded between the terminal forks of the maxillary arm of the zygoma.

The jugals are but slightly (sometimes not at all) expanded anteriorly, in which respect the species agrees with *P. planiceps*, from the Volcano of Toluca. It differs from the latter greatly in the extent to which the jugal enters into the formation of the zygomatic arch; the jugal being so far overlapped by the maxillary and squamosal roots of the arch that its free upper border is short—less than half the length of the basioccipital in median line. It differs from *planiceps* further in broader rostrum, less spreading and more strongly decurved zygomata, and shorter and broader ascending arms of the premaxilla, which are bluntly rounded off opposite the middle of the maxillary root of the zygoma.

Measurements.—Average of seven males from type locality: Total length, 287.5; tail vertebræ, 82.2; hind foot, 42. Average of three females from type locality: Total length, 277; tail vertebræ, 75.3; hind foot, 39.6.

For cranial measurements see Table E, p. 213.

Specimens examined.—Total number, eleven; all from Colima City, Colima, Mexico.

General remarks.—*Platygeomys fumosus* belongs to the *gymnurus* series, of which it is the smallest species yet described. It differs markedly from the other members of the series in having the zygomatic arches rounded and nearly parallel instead of sharply angular and strongly diverging anteriorly; and differs further in having the sides and rump beset with whitish bristles that protrude far beyond the fur.

The original description of this species was faulty in several respects and is here corrected. The material collected by Mr. Nelson since the original description was published has thrown a flood of light not only on the affinities of this species but also on the whole group. It is now clear that *fumosus* is not related in any way to *hispidus*, authentic skulls of which are now available for the first time.

Mr. Nelson found this species limited in distribution. His notes state that it was rather numerous in damp saline flats overgrown with cocoanut palms, wild fig trees, mesquites, and acacias, in the valley of the Colima River near the city of Colima. In the vicinity of Armeria, at an altitude of about 200 feet, a few hills were seen but none of the animals were caught. Thence up the course of the Armeria river, on the plain of Colima the hills became more and more numerous, especially between the altitudes of 800 and 2,500 feet. The animals seem to live in isolated and limited colonies, between which, in apparently equally favorable ground they occur singly and rarely. One colony of considerable size occupies an open grassy area in the limestone belt between Colima and the volcano; others were seen along the sandy border of the Armeria river bottom in a growth of low bushes, and in some thick thorny woods on a dry bench bordering the Colima river a few miles below the city.

Genus ORTHOGEOMYS* nob.

(Pl. 19, figs. 1 and 2; text figs. 60–64; map 3[5].)

Type Geomys scalops Thomas, from TEHUANTEPEC, MEXICO.

Dental characters.—Upper premolar with three or four enamel plates, the posterior when present restricted to inner fourth; † m^1 and m^2 with two enamel plates each. Third upper molar with an elongated heel and deep outer sulcus; inner sulcus variable; both inner and outer enamel plates normally reaching posterior end of heel, the inner plate usually covering the posterior half of the inner side of the tooth, leaving a broad cement band in front of it (fig. 34, [7], [8], and [9]). In *O. scalops* the outer plate is often divided, presenting an anomalous condition in the family (fig. 62). Posterior curvature of m^1 and m^2 and anterior curvature of m_1 and m_2 strongly developed. Shaft of upper pm straight.

Upper incisor *unisulcate*, the sulcus widely open and slightly on inner side, but sometimes reaching middle.

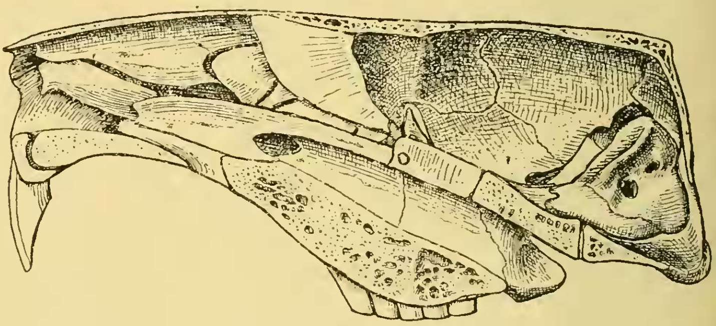

FIG. 60.—*Orthogeomys scalops.* Longitudinal vertical median section of skull, mesethmoid and vome in place. (For key see fig. 7.)

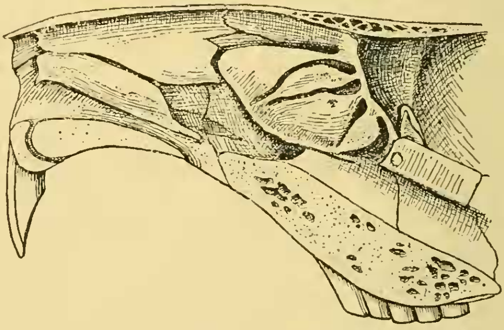

FIG. 61.—*Orthogeomys scalops.* Mesethmoid and vomer removed, showing endoturbinals. (For key see fig. 10.)

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* *Orthogeomys*, from ὀρθός, straight, + *Geomys*, in reference to the unusual shap of the skull.

†The posterior plate is present in both upper premolars of the type and only know specimen of *O. latifrons*, but is altogether absent, or present as a very narrow stri on one side only, in *O. scalops* and *O. nelsoni*.

Skull as a whole much elongated; frontal extraordinarily broad and flat, much broader than muzzle, with sides nearly parallel (not excavated or concave laterally between the orbits, fig. 17[4]); orbital plates of frontal not meeting inferiorly behind cribriform, but broadly separated by orbitosphenoids, as in *Pappogeomys* and *Thomomys*. Zygomata narrow or only moderately spreading. Brain case subcylindric, as seen from above, in continuation of the general form of the frontal and muzzle. Angle of mandible short. Orbitosphenoids rather large, articulating with the anterior part of the alisphenoids and sending a tongue upward, partly filling the upper part of the sphenoidal fissure (fig. 60). Mesethmoid a half crescent, as in *Cratogeomys;* endoturbinals as a whole quadrangular, the anterior border essentially parallel to cribriform plate; first endoturbinal only slightly expanded and rounded anteriorly, as in *Geomys;* third endoturbinal larger and much broader than second—a unique condition in the family (fig. 61). The palatopterygoids are long and narrow, and of nearly equal breadth throughout; the basal third or less, is palatine; the distal two-thirds or more, pterygoid. The foramen rotundum and foramen ovale are nearer together than usual, and sometimes merge into a single large opening which communicates directly with the alisphenoid canal.

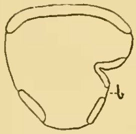


FIG. 62.—*Orthogeomys scalops.* Last upper molar. *b*, divided outer enamel plate.

External characters.—Size large; pelage very coarse, hispid or setose; nasal pad present or absent.

Cranial characters.—The chief cranial characters that distinguish *Orthogeomys* from the other genera having essentially the same enamel pattern of the molariform series (*Heterogeomys* and *Macrogeomys*)* are the great breadth of the frontal interorbitally, absence of interorbital constriction, absence of conspicuous postorbital prominences or ridges, large size and extended relations of orbitosphenoids, peculiar form of endoturbinals, and shape of the palatopterygoids. The great length and narrowness of the cranium as a whole is matched by *Macrogeomys dolichocephalus*, but the nearly uniform breadth of the upper part of the skull and the form of the zygomata and palatopterygoids are very different. The posterior position of the lateral enamel plates of m^3, both of which normally reach the end of the heel, is a distinctive character.

KEY TO SPECIES OF ORTHOGEOMYS.

Pelage setose; muzzle short .... *latifrons.*
Pelage not setose; muzzle long:
  Frontal inflated on orbital margin anteriorly; m^3 normal—
    Nasals broad posteriorly .... *grandis.*
    Nasals narrow posteriorly .... *nelsoni.*
  Frontal inflation slight or absent; m^3 with outer enamel plate divided .. *scalops*

*It has been stated in the preceding footnote that the upper premolar of *Orthogeomys* normally has only three enamel plates, while in *Heterogeomys* and *Macrogeomys* four are always present. Hence the enamel pattern can hardly be said to be the same.

ORTHOGEOMYS SCALOPS (Thomas).

(Pl. 19, figs. 1 and 2, and text figs. 60–62.)

Geomys scalops Thomas, Annals and Mag. Nat. Hist., 6th series, XIII, May, 1894, 437–438.

Type from TEHUANTEPEC, MEXICO. (Type in British Museum).

Geographic distribution.—Extreme southern Mexico, in State of Oaxaca, and probably adjacent part of Chiapas.

Mr. Nelson states that on the pine-covered slopes of the Cerro San Felipe, a few miles north of the city of Oaxaca, he found the diggings of this gopher extending upward from an altitude of about 7,000 feet to the summit (altitude about 10,500 feet), always in pine or oak timber or in the small openings that occur in the forest.

General characters.—Size rather large; pelage hispid; naked nasal pad large (measuring 20 mm. in length in fresh specimen); tail naked; hind feet naked, except for a few scattered colorless hairs; ear opening surrounded by a broad, thickened rim.

Color.—Type specimen in worn, faded pelage: "Smoky-brown, tending rather toward rufous (very near 'Prout's brown' of Ridgway)."—Thomas. An adult specimen from Cerro San Felipe, Oaxaca, collected June 21, 1894, by E. W. Nelson, is in good pelage and is dark seal-brown (almost black in places) with an evident gloss.

Cranial characters.—Skull of adult ♀ very long and narrow; frontal very broad interorbitally, not constricted in front of postorbital processes; zygomata little spreading, flattened, elongated antero-posteriorly, the outer sides parallel; occipital plane sloping forward; paroccipital flanges turned backward, but not reaching plane of occipital condyles; palatopterygoids narrow, of nearly uniform breadth throughout, the pterygoids forming distal two-thirds, but not reaching base of notch (see pl. 19, fig. 2). Inferiorly the premaxilla reaches far behind the incisive foramina. Contrasted with *latifrons*, which it greatly resembles, *scalops* differs in having the rostrum much longer, the nasals broader, more arched anteriorly, and longer, and the jugal broader anteriorly. The resemblances and differences are such as to at once suggest sexual variation—the skull of *O. latifrons* differing from that of *scalops* in the way that female skulls usually differ from males in the *Geomyidæ*—smaller size, shorter rostrum, and narrower jugals. But, unfortunately for this hypothesis, the specimen of *scalops* is an adult female, as shown both by the collector's label and by the conspicuous teats on the dry skin. Furthermore, the grooving of the upper incisors is very different and the external characters are marked.

Since the above was written I have received nine additional specimens of *O. scalops* from Mr. Nelson, all collected in the Cerro San Felipe, near the city of Oaxaca, during the last week of August and 1st of September, 1894. Two of these are adult males. Their skulls differ from those of the female in slightly larger size; more spreading and somewhat heavier zygomata, which divaricate anteriorly instead of being parallel; in a more decided tendency to inflation of the anterior part of

the border of the frontal; the development of a long sagittal ridge, and of much larger paroccipital processes, which reach backward behind the plane of the condyles.

Male skulls of *scalops* from Cerro San Felipe, Oaxaca, differ from males of *nelsoni* from Totontepec and Mount Zempoaltepec, Oaxaca in the following characters: Size smaller, muzzle much narrower, the narrowness especially marked in the ascending branches of the premaxilla; nasals decidedly broader posteriorly and less evenly acuminate, spreading more abruptly in front of the middle; zygomatic arches more slender and more divergent anteriorly; frontal inflation less pronounced; paroccipital processes much larger and directed more strongly backward, exceeding the plane of the condyles; occipital plane less flattened, and marked by three ridges, a median ridge and two lateral; palatopterygoids shorter; groove of upper incisors narrower.

Dental characters.—Molars as in the genus. Upper incisors with a single deep and rather broad furrow wholly on inner side; outer side strongly convex. In *latifrons* the groove is relatively shallow and median, or nearly so. The outer enamel plate of the last upper molar is usually divided, making four instead of three plates for this tooth, a condition not observed elsewhere in the family (fig. 62).

Measurements.—Type specimen (measured by Thomas from dry skin): Head and body, 270; tail, 95; hind foot, 45.2 (without claw, 40).

Average of two males from Cerro San Felipe, Oaxaca (measured in flesh): Total length, 369; tail vertebræ, 103.5; hind foot, 50.*

Average of eight females from same place: Total length, 360; tail vertebræ, 109; hind foot, 50.

Cranial measurements.—Type specimen (measured by Thomas): Basal length, 63; basilar length of Hensel, 56.7; greatest zygomatic breadth, 40.8; nasals, length 26, greatest breadth, 8; least breadth of muzzle above maxillo-premaxillary suture, 15; interorbital breadth, 14.2; between tips of postorbital processes, 16.2; postglenoid breadth, 26.7; greatest squamosal breadth, 39; basion to occipital crest, 18.4; between tips of paroccipital processes, 27.5; palate from gnathion, 47; diastema, 24.5. Upper molar series on crowns, 12.6; breadth of m^1, 4; least height of muzzle on diastema, 12.

For other cranial measurements see Table F, p. 214.

Specimens examined.—Total number 13: 10 from Cerro San Felipe, Oaxaca, Mexico; 3 from mountains 15 miles west of city of Oaxaca.

General remarks.—*Orthogeomys scalops* seems to be more closely related to *O. grandis* than to *O. nelsoni*.

ORTHOGEOMYS GRANDIS (Thomas).

(Text fig. 63.)

Geomys grandis Thomas, Annals and Magazine Nat. Hist., 6 ser., XII, October, 1893, pp. 270-271.

Type locality.—DUEÑAS GUATEMALA. (Type in British Museum).

*A larger series of males would undoubtedly result in larger average measurements, as neither of our specimens are very old.

Geographic distribution.—"Common all over the highlands [of Guatemala], and traces of their presence are to be met with almost everywhere in the neighborhood of Dueñas."—Biologia Centrali-Americana, Mammalia, 1880, 160.

General characters.—Size very large; upper incisors deeply unisulcate, the sulcus on inner side and widely open; tail naked; fore and hind feet "very thinly haired, the few scattered bristles whitish;" pelage coarse. The following quotation is from Mr. Thomas's description of the type specimen:

Color.—"Smoky chocolate brown throughout, except on the muzzle, cheeks, and chin, where the hairs are white or pale whitish brown. A few white hairs scattered over the back."

Cranial characters.—"Skull large and heavily built. Ascending processes of premaxillaries surpassing the nasals by about a quarter of an inch; the space between them behind the nasals less than the breadth of one of them. Interorbital space broad, as broad as the muzzle, its edges anteriorly rounded and inflated in a manner quite unique. Zygomata not very widely expanded in proportion to the size of the skull.

"Incisors pale yellow or whitish, in marked contrast to the deep orange found in the allied species. Their single groove deep and very widely open, so that its greatest width on the cutting edge amounts to 2 mm.; in position the bottom of the groove is internal, the breadth of the inner portion of the tooth being about 43 to 45 percent of the whole; owing, however, to the great breadth of the groove itself, it considerably overlaps the median line, but the above percentage is taken strictly from the bottom of the groove. Molar teeth large."*

Measurements of type specimen (from dry skin).—Head and body, 320; tail, 135; hind foot, with claw, 57; without claw, 50; longest foreclaw, 23. For cranial measurements see Table F, (p. 214).

General remarks.—This animal, though long known from Guatemala, had been confounded with *hispidus* until recently separated by Mr. Thomas, who, struck by its larger size and some other external differences, removed the skull from one of Mr. Salvin's original Dueñas specimens and discovered the remarkable cranial peculiarities above mentioned.

ORTHOGEOMYS NELSONI sp. nov.

(Text fig. 63.)

Type from MT. ZEMPOALTEPEC, OAXACA, MEXICO. (Altitude 8,000 feet.) No. 66751 ♂ ad. U. S. National Museum, Department of Agriculture Collection. Collected July 8, 1894, by E. W. Nelson and E. A. Goldman. Original No. 6376.

Geographic distribution.—Mt. Zempoaltepec in the State of Oaxaca, Mexico, and the adjacent region, including Comaltepec and Totontepec.

General characters.—Size, largest of the known species of the family, slightly exceeding *O. grandis* of Guatemala, which it closely resembles, differing chiefly in the fronto-nasal region of the skull. Ears larger than in any other member of the family; naked nasal pad large; tail naked except at base.

* Annals and Magazine Nat. Hist., XII, October, 1893, 270–271.

Color.—Uniform dull dark-brown; hardly paler below.

Cranial characters.—Skull large, long, and heavy, resembling both *scalops* and *grandis*, but differing from both in the shape of the nasal bones, which are *very much narrower posteriorly*. Mr. Oldfield Thomas has had the kindness to compare his type of *grandis* with the type and other skulls of *nelsoni* sent him for the purpose, and has taken the trouble to give me a sketch of the fronto-nasal region of *grandis*, with a number of detailed measurements which show the differences between the two forms. In addition to the striking narrowness of the nasals posteriorly, *nelsoni* differs from *grandis* further in the following points: the ascending arms of the premaxilla reach much further backward, cutting the plane of the orbit; the articular face of the maxillary root of the zygoma (on top of the skull) is much longer, measuring 11.5 instead of 8.7 mm.; the frontal is both narrower and shorter between the nasal branches of the premaxilla; the muzzle is narrower, the frontal broader, and the frontal inflations are more anterior and less extreme. The mandible differs, not only from *grandis*, but from all known members of the family in the absence of the capsular inflation over the root of the incisor, between the condyle and angular process. It is entirely wanting in the type, and only faintly apparent in the adult female from the same locality. It is larger, but still abnormally small, in an old male from near *Totontepec* (No. 66753). The skull of the latter specimen is the largest I have seen of the species and the jugal is broader anteriorly than in the specimens from Mount Zempoaltepec.

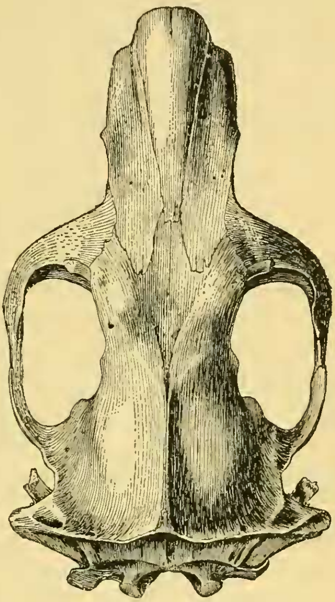


FIG. 63.—*Orthogeomys nelsoni* ♂ type (natural size). From Mount Zempoaltepec, Oaxaca, Mexico.

Skulls of *O. nelsoni* differ from those of *O. scalops* in larger size, much broader muzzle, heavier zygomata, longer nasals, which are much narrower posteriorly and truly cuneate in form; much broader ascending branches of premaxilla; broader and decidedly more inflated frontal; U-shaped, instead of V-shaped postglenoid notch; flatter occipital plane, with less backward extension of the paroccipital processes.

Measurements.—Type specimen, an adult ♂ from Mount Zempoaltepec: total length, 397; tail, 123; hind foot, 53. Another male, from near Totontepec, is even larger: total length, 435; tail, 140; hind foot, 55. An adult female from Mount Zempoaltepec measures: total length, 380; tail, 118; hind foot, 52.

For cranial measurements see Table F, p. 214.

Specimens examined.—Five, all from the State of Oaxaca, southern Mexico: Mount Zempoaltepec, 2; near Totontepec, 2; Comaltepec, 1.

General remarks.—In color the specimens of *O. nelsoni* differ materially from Mr. Thomas's description of *grandis*. They are in worn pelage, and are very dark-brown, but the muzzle and cheeks are not paler. In fresh pelage they would probably resemble *O. scalops* in being rich seal-brown, almost black. The feet are evidently more hairy than those of *grandis*, and the ears are larger than in any other member of the family, measuring about 5 mm. in height in the dry skin.

ORTHOGEOMYS LATIFRONS sp. nov.

(Pl. 11, figs. 5 and 6; text fig. 64.)

Type from GUATEMALA. Exact locality unknown. No.——. U. S. National Museum (No. 2 World's Fair exhibit of Guatemala).

General characters.—Size medium (rather small for the tropical American species); incisor groove median or nearly so; tail long and absolutely naked; hind feet naked, except a few scattering hairs; forefeet scant haired; nasal pad small or absent; pelage hispid, scant and unusually long, unlike any known species of the family. The individual hairs are bristles, very much coarser and longer than those of *Geomys hispidus*. There is no under fur. The belly is so sparsely haired that the bare skin shows through.

Color.—Everywhere uniform dull sooty-brown.

Cranial characters—Unfortunately the skull of the type and only known specimen of this remarkable animal is defective, the entire occipital region and the audital bullæ being absent. The anterior part of the skull is perfect, including all of the teeth and one of the zygomatic arches. The upper surface of the cranium is remarkably smooth and free from lateral indentations or projections, and is of almost uniform breadth. Seen from above, the muzzle, frontal, and brain case pass into one another without interruption or constriction, the frontal being a trifle wider than the muzzle and the cylindrical brain case a trifle broader than the frontal. There is only a faint attempt at a postorbital prominence, and it is below the level of the top of the skull and is made up of the alisphenoid and squamosal. The muzzle is short. The zygomata are narrow and slender, without any enlargement or expansion at any point; they are broader posteriorly than anteriorly, and the maxillary arm slopes strongly backward. The jugal is small and slender and the arch is incomplete without it. The palatopterygoids are broken off. The ascending branches of the premaxilla slightly surpass the plane of the orbits. Inferiorly the premaxilla slightly passes the posterior end of the incisive foramina. The nasals are small, short, and narrow, but slightly broader anteriorly than posteriorly, and without trace of inflation. The angles of the mandible are short and flat. Unfortunately the palatopterygoids and audital bullæ are broken off, along with the whole of the occipital region, hence additional important characters may exist that are not apparent in the single specimen at hand.

Dental characters.—The single groove of the upper incisors is median, open, and rather shallow, and the face of the tooth slopes toward it from both sides. It thus differs widely from the deep and abrupt groove of *G. scalops*, which is wholly on the inner side. The face of the incisors is orange; in *scalops* it is pale yellowish or straw-color. The long axes of the crowns of the individual molars are not quite transverse, but slope slightly backward toward the median line. In most species they slope forward. The heel of the last upper molar is short, but is sharply circumscribed. In addition to the usual deep sulcus on the outer side, the inner side is abruptly narrowed (figs. 34[7] and 64). The enamel plates are peculiar: *Inner enamel plate* covering considerably more than half of inner side of tooth, its anterior end bent outward at nearly a right angle; its posterior end curved toward the median line and reaching the hindermost part of the heel; *outer enamel plate* covering about five-sixths of the outer side of the tooth, its anterior third bent outward at right angles, its posterior half sloping strongly backward to the end of the heel, forming nearly a right angle with the middle part and thus making two sharp angles instead of one—a unique condition. The posterior interspace is very narrow and is on the median line of the tooth behind. The inner interspace is twice as broad as the posterior.

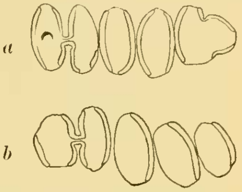


FIG. 64.—*Orthogeomys latifrons* (type). Crowns of molariform teeth: *a* upper; *b* lower.

Measurements (from dry skin, not overstuffed).—Total length, 320; head and body, 235; tail. 100; hind foot with claw, 44; hind foot without claw, 39.

General remarks.—Externally *Orthogeomys latifrons* may be distinguished from all other known members of the *Geomyidæ* by the character of the pelage, which is setose, the individual hairs being long bristles. In cranial characters it closely resembles *O. scalops*, but differs in the much shorter muzzle and nasals (which latter are not at all inflated anteriorly), and narrower jugal. The upper incisors are very unlike. In *latifrons* the face is orange, the groove median, or nearly median, and relatively shallow, and both sides slope similarly into it. In *scalops* the face is pale yellowish or straw color, the groove wholly on the inner side and deep and abrupt, and the outer side is strongly (roundly) convex.

Genus HETEROGEOMYS * nob.

(Pl. 4; pl. 14, fig. 12; pl. 15, fig. 2; pl. 17, fig. 1; pl. 18, fig. 3; pl. 19, fig. 5; text figs. 65 and 66; map 3[4].)

Type Geomys hispidus LeConte, from near JALAPA, VERA CRUZ, MEXICO.

Dental characters.—Upper premolar with four enamel plates, the posterior restricted to inner or lingual half. Upper and lower premolars

* *Heterogeomys*, from ἕτερος, different, + *Geomys*.

subequal in length. First and second upper molars with two enamel plates each, the posterior complete. Third upper molar a double prism; crown much longer than broad; posterior loop or heel strongly developed; outer sulcus deep; inner sulcus slight; inner enamel plate covering half or more than half of inner side of tooth and falling short of hinder end of heel; outer enamel plate very long, covering the whole of the outer side of the tooth behind the anterior cement band, and curving inward posteriorly to the median line of the tooth. At the lateral sulcus the outer enamel band bends outward at right angles. Posterior curvature of m^1 and m^2 and anterior curvature of m_1 and m_2 slight. Shaft of upper pm straight or faintly convex forward. Upper incisor unisulcate, the sulcus wholly on inner side of median line and sometimes on inner third; deep and abrupt (fig. 20^2).

Cranial characters.—Skull as a whole high and narrow; frontal broad and flat; its sides biconcave interorbitally; distance between orbits much greater than length of basioccipital on median line; temporal impressions anteriorly defining a marked frontal shield (fig. 17^2); orbital plate of frontal usually perforated by a foramen above apex of sphenoidal fissure; zygomatic arches variable, outer sides nearly parallel, antero-external angle sharp and moderately expanded; inferior surface of palatopterygoids cuneate-lingulate, long and slender, the palatal arms much elongated, the pterygoid part small and terminal; postpalatal pits deep; nasals much arched anteriorly to support the large nasal callosity; occipital plane but little more than twice as broad as high, very flat, sloping strongly forward from below upward, squamosal part very high above mastoid bullæ; orbitosphenoids shield-shaped, rather narrow and long, not articulating with alisphenoids;* upper part of optic foramen disappearing in advanced life (pl. 17, fig. 1); endoturbinals peculiar, the first greatly expanded, its anterior face vertical or slightly emarginate (pl. 19, fig. 5). Mesethmoid rather small and strongly convex anteriorly (pl. 18, fig. 3). Squamosal expansion slight; fronto-maxillary suture reaching orbit in front of lachrymal (instead of behind, as usual). Mandible short and compact; angular processes short.

KEY TO SPECIES OF HETEROGEOMYS.

Zygomata broadly spreading, divergent anteriorly; nasals short .... *torridus.*
Zygomata not broadly spreading and not divergent anteriorly; nasals rather long .... *hispidus.*

*In immature skulls of *Heterogeomys* the orbitosphenoid seems to articulate anteriorly with the maxilla as well as the frontal, but careful examination shows it to be separated by the narrow descending arm of the frontal. In rare cases, irregular absorption of the exceedingly thin plate may permit the orbitosphenoid to reach the maxilla.

HETEROGEOMYS HISPIDUS (LeConte).

(Pl. 4; text fig. 65; pl. 13, fig. 20; pl. 14, fig. 12; pl. 15, fig. 4.)

Geomys hispidus LeConte, Proc. Acad. Nat. Sci., Phila., V, September, 1852, 158.

Type locality.—Near Jalapa, Vera Cruz,* Mexico. (Type in Acad. Nat. Sciences, Phila.)

Geographic distribution.—The 'Tierra Templada,' or middle belt, along the basal slope of the table-land, in the State of Vera Cruz, Mexico, between the altitudes of 4,000 and 4,500 feet. Mr. Nelson found the species common about Jalapa and Jico, and in less abundance from near the city of Orizaba north to Huatusco. The U. S. National Museum contains a specimen from Necostla (near Orizaba).

General characters.—Size large; upper incisors deeply unisulcate, the sulcus wholly on inner side; tail naked; a large naked pad on end of nose; forefeet with claws shorter than hind; pelage harsh and stiff, unlike any other species known to occur in Mexico except *torridus.*

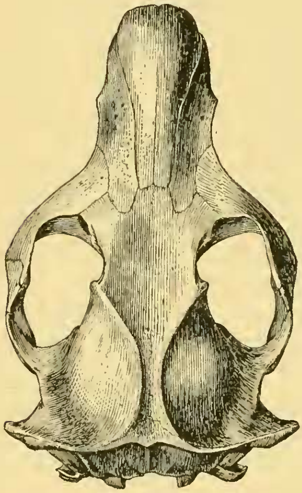
Color.—Upper parts everywhere uniform dark seal-brown;† hardly paler below.

Cranial characters.—Skull as a whole high and narrow; frontal very broad and flat, depressed and biconcave interorbitally, concave both longitudinally and transversely; distance between orbits much greater than length of basioccipital on median line; temporal impressions forming elevated semicircular ridges separated in both sexes by a distinct interval, and extending from postorbital prominences to outer angles of interparietal, anteriorly defining a marked frontal shield, and posteriorly inclosing a broad interparietal; zygomatic arches narrow, the maxillary arms sloping strongly backward, outer sides nearly parallel (sometimes broadest across the middle instead of anteriorly), antero-external angle sharp and moderately expanded, but not in the usual way; angle not produced downward; expansion oval in shape and encroaching on orbital fossa, which is correspondingly narrowed at this point; inferior surface of palatine bones greatly elongated posteriorly, forming, on either side of the postpalatal notch, narrow lingulate extensions which are terminated by short and narrow pterygoids; postpalatal pits deep; ascending branches of premaxilla broad and bluntly rounded posteriorly; premaxilla extending far enough posteriorly to inclose incisive foramina; nasals inflated anteriorly and then contracted at nares; anterior nares larger than in the other groups; occipital plane a little more than twice as broad as high, very flat (free

* The type specimen was collected by Mr. Pease in 1847 on the road followed by Scott's army "between Vera Cruz and the City of Mexico," which road passes through Jalapa. Mr. Nelson found the species abundant about Jalapa, which is in the 'Tierra Templada,' about halfway down the slope from the table-land to the coastal plain. He ascertained further that the species does not occur on the table-land, which is inhabited by other genera.

† This color may be otherwise described as very dark plumbeous, faintly tinged with purple.

from the projections and irregularities common to other forms), sloping strongly forward from below upward; brain case larger, more clearly defined, and higher above posterior root of zygoma than in any other group; squamosal expansion minimum, neither extending out far laterally nor increasing length of glenoid fossa anteriorly—the usual shelf-like projection into the orbito-temporal fossa from the posterior root of the zygoma being nearly obsolete; fronto-maxillary suture reaching orbit in front of lachrymal (instead of behind it as usual). This arrangement broadens the frontal anteriorly, shortening and apparently weakening the attachment of the maxillary root of the zygoma. Mandible short and compact, little spreading posteriorly; angular process short; prominence over root of incisor low and flattened posteriorly; condylar process long and only slightly sloping inward.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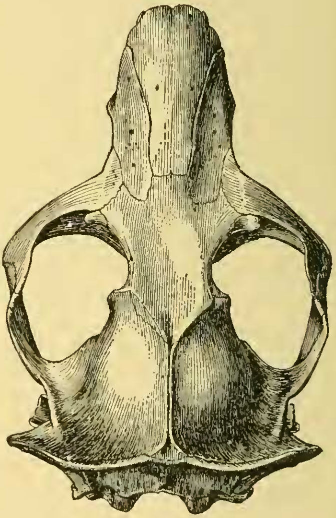
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Fig. 65.—*Heterogeomys hispidus.* Jico, Vera Cruz, Mexico. (Nat. size.)
Fig. 66.—*Heterogeomys torridus.* Motzorongo, Vera Cruz, Mexico. (Nat. size.)

Dental characters.—Front face of incisors perfectly flat, not rounded off on edges as in *Geomys*, *Platygeomys*, and *Zygogeomys.* Upper incisors deeply unisulcate, the groove narrow and wholly on inner side. Lower incisors without bevel or groove on outer face. Molars larger, heavier, and less flattened antero-posteriorly than in *Geomys* or *Zygogeomys;* crown of last upper molar elongated posteriorly and abruptly narrowed behind lateral sulcus, the crown of posterior prism longer than anterior, to which it forms a distinct heel. Isthmus connecting anterior and posterior lobes of upper premolar decidedly on inner side of tooth.

Measurements (taken in flesh).—Average of two males from near type locality (Jico, 7 miles south of Jalapa, Vera Cruz): Total length, 345;

tail vertebræ, 92.5; hind foot, 53. Average of three females from same place: Total length, 310.6; tail vertebræ, 85.3; hind foot, 47.3.*

For cranial measurements see Table F, p. 215.

Specimens examined.—Total number 9, from the following localities in the State of Vera Cruz, Mexico: Jico, 6; Huatusco, 1; Necostla, 1; locality unknown, 1.

General remarks.—Through the courtesy of Mr. Witmer Stone and other officers of the Academy of Natural Sciences of Philadelphia, the type specimen of *Geomys hispidus* has been sent me for examination. In size, character of pelage, and all other respects except color, it agrees almost exactly with Mr. Nelson's specimens. The color, which LeConte described as "reddish-brown" and Baird as "reddish-brown or dull chestnut," was probably the result of museum exposure, the skin being mounted and exposed to the light. It was collected by Mr. Pease in 1847, during the march of Scott's army from Vera Cruz to the City of Mexico, and consequently had been in the collection five years before it was described by LeConte. The fading has continued, the specimen now being much paler than when seen by Baird in 1855.

In view of the large number of species of Pocket Gophers now known to inhabit southern Mexico, it is exceedingly gratifying to be able to settle the status of *hispidus* by actual comparison of the type specimen with the series collected by Mr. Nelson at or very near the original type locality. The skull of the type specimen has never been removed, and the cranial characters of the species have remained unrecorded until the present time. The series of skulls obtained by Mr. Nelson therefore were examined with unusual interest and the result was a complete surprise. They show not only that the animal is a strongly marked species, but that it is generically distinct from *Geomys*, as already pointed out.

The naked nasal pad is more largely developed in this species than in any of the others, and its large size is clearly correlated with the inflated nasal bones. For this reason it shows to unusual advantage in the type specimen, which is mounted with the skull inside, the arched nasals keeping it stretched in its natural relations. In this specimen it measures 12.5 mm. in length by 10 in breadth.

Mr. Nelson states that *H. hispidus* is confined to the district suitable to the cultivation of coffee and sugar cane and is said to be very injurious to cane plantations.

HETEROGEOMYS TORRIDUS sp. nov.

(Pl. 15, fig. 2; pl. 17, fig. 1; pl. 18, fig. 3; pl. 19, fig. 5; text fig., 66.)

Type from CHICHICAXTLE, VERA CRUZ. No. 63629 ♀ ad., U. S. National Museum, Department of Agriculture collection. Collected February 15, 1894, by E. W. Nelson. (Original number, 5850.)

Geographic distribution.—Lowlands of Vera Cruz, from Chichicaxtle

*The measurements of the feet of the mounted type specimen as taken by me now, nearly half a century after its capture, are: Forefoot from basal pad to tip of longest claw, 42.5; hind foot from heel to tip of longest claw, 45.5.

and Motzorongo to Catemaco, and thence into Guatemala; penetrating the interior to Reyes, Oaxaca, and Guatemala City, Guatemala.

Mr. Nelson first observed this species on the way from Mirador to the coast, from an altitude of about 1,500 feet near Santa Maria, down to the border of the sand hills along the coast at Antigua. The next point where it was noted was on the route from the city of Cordoba to the hacienda of Motzorongo. At an altitude of 800 feet at this latter place it was again found in abundance. The easternmost locality at which it was obtained by Mr. Nelson is Catemaco, in the district of Tuxtlas. He afterwards secured it at Reyes, in northern Oaxaca, at an altitude of 6,700 feet. The range of the species is strictly tropical.

General characters.—Similar to *H. hispidus.* Size large; tail naked; naked nasal pad large; hind feet nearly naked; fore feet scant haired.

Color.—Everywhere dark seal-brown, only slightly paler below; in worn pelage chocolate brown.

Cranial characters.—Skull large, heavy and rather broad, resembling that of *H. hispidus*, from which it differs in the following particulars: Pituitary fossa deeper and (usually?) perforate; zygomata much more squarely spreading anteriorly (the maxillary arm standing out at more nearly a right angle instead of sloping strongly backward); temporal impressions uniting posteriorly in old of both sexes, but not rising in a sagittal crest; audital bullæ smaller, narrower anteriorly, and not sending up a point or ridge toward hamular process of pterygoid; ascending arms of premaxilla averaging broader and shorter posteriorly. The skull of the male differs from that of the female in larger size and greater angularity. The zygomata reach out much further sideways, are much broader anteriorly than across the middle, and the outer angle stands out prominently (in the female it turns downward). The jugal is considerably larger and broader anteriorly in the male.

Measurements (taken in flesh).—Type specimen (♀ ad. from Chichicaxtle): Total length, 323; tail vertebræ, 88; hind foot, 52.

Average of four adult males from Motzorongo: Total length, 348; tail vertebræ, 96.5; hind foot, 49.2.

Average of ten adult females from Motzorongo: Total length, 317; tail vertebræ, 81.5; hind foot, 45.5. The ♀ from Reyes, Oaxaca, is decidedly larger, measuring: total length, 332; tail, 98; hind foot, 49.5.

The mounted specimen in the World's Fair exhibit from Guatemala, which is considerably overstuffed, now measures: Total length, 380; tail vertebræ, 85; hind foot, 46. It is a female.

For cranial measurements see Table F, p. 215.

Specimens examined.—Total number 27: 2 from Guatemala; 1 from Reyes, Oaxaca, and 24 from the following localities in Vera Cruz, Mexico: Chichicaxtle (type locality), 1; Motzorongo, 22; Catemaco, 1.

General remarks.—*Heterogeomys torridus* differs but little externally from true *hispidus.* Even in color the type specimen, which is in worn pelage, except on the head, is only a shade paler than specimens of *his-*

pidus in worn pelage. The differences in cranial characters, however, are marked and constant. Still it is quite possible that intergrades may be found in the exceedingly narrow belt separating the two forms. It should be observed that the type specimen has a hind foot 4 mm. longer than the largest female from Motzorongo, and that the skull, also, is larger. The type is a very old individual.

Two specimens of a *Heterogeomys* from Guatemala, belonging to the U. S. National Museum collection, are here referred to the present species. One of these, a young adult (No. $\frac{2019}{22550}$) was collected many years ago near Guatemala City by Dr. Van Patten; the other was recently presented to the Museum by the Guatemala Commissioners to the World's Fair. The exact locality where it was obtained is unknown. It is an old female, and the temporal impressions meet over the middle part of the sagittal suture (which is obliterated, as in all adults of the species). The specimen obtained by Dr. Van Patten (probably also a female) is younger, and the temporal impressions are still distant. The two Guatemala skulls differ from those from Vera Cruz in having the postorbital prominence obsolete or nearly so.

Mr. Nelson states that in Vera Cruz this species is one of the most injurious of the genus to the agriculturist. At Catemaco he found it in small numbers among the dry hills and plains on the western border of the lake, but in the forest on the eastern shore it swarms in countless numbers. At one point the ground was fairly honeycombed with their tunnels, so that he sank to the knee at nearly every step.

Hetergeomys torridus becomes sexually mature at a remarkably early age. Several of the young females were mothers, and one in particular, though hardly half grown, has long pendant teats that have evidently been nursed. This specimen (No. 63640) is still in the woolly pelage of the very young, and its skull, barely half the size of the adult, has not yet attained the mature form. The animal could hardly be more than three months old. Its measurements in the flesh are: Total length, 259; tail vertebræ, 71; hind foot, 43.

Genus MACROGEOMYS* nob.

(Pl 5; pl. 11, figs. 2 and 3; pl. 13, figs. 18, 19, 22, and 23; pl. 14, figs. 3 and 10.)

Type Geomys heterodus Peters, from Costa Rica.

Dental characters.—Upper premolar with four enamel plates, the posterior restricted to inner third; m^1 and m^2 with two enamel plates each. Last upper molar with an elongated heel and deep outer sulcus; inner emargination variable (slight in *heterodus;* deep in *dolichocephalus*); inner enamel plate covering half to two-thirds of inner side of the tooth, its posterior end nearly reaching hinder end of heel. *Outer enamel plate* variable, the posterior limb double the length of the anterior. In *M. heterodus* it covers half; in *dolichocephalus* and *costari-*

* *Macrogeomys*, from μακρὸς, large, great, + *Geomys*, in reference to the large size of the animals.

censis, three-fourths of the outer side of the tooth. The posterior loop or heel is greatly developed, attaining the maximum size known in the family (about half or more than half the length of the tooth and narrow, the constriction about half the breadth of the anterior prism).

Posterior curvature of m^1 and m^2 and anterior curvature of m_1 and m_2 strongly developed. Shaft of both upper and lower premolar strongly convex forward and very large and heavy.

Upper incisor *unisulcate*, the sulcus wholly on inner third of face, narrow and deep; face of tooth flat on both sides of sulcus (fig. 20[1], and pl. 15, fig. 8).

Cranial characters.—Frontal broad, flat, depressed or concave along the median line, deeply excavated laterally between the orbits, the notch immediately succeeded by a strongly developed postorbital process (much larger than in any other member of the family, fig. 17[3]). Palatopterygoids broad, short, and truncated posteriorly, the horizontal part composed almost wholly of the palatal, the pterygoid simply capping the end and abruptly upturned at right angles (fig. 11[5]). Nasals moderately convex, slightly or not inflated. Brain case rising high above posterior root of zygoma. Unfortunately there are no skulls of *Macrogeomys* in the Department collection; hence I have been unable to make sections to expose the mesethmoid and turbinals.

The lambdoid crest is straight or slightly convex posteriorly (not sinuous as in *Platygeomys*) and the occipital plane is flat and slopes strongly forward, as in *Heterogeomys*.

External characters.—Size large; naked nasal pad well developed; tail naked; pelage soft, almost silky, and with a tendency to become wavy; color pattern unique, bicolor: muzzle and sides of rump abruptly whitish; rest of upper parts dark chocolate or sepia in marked contrast. (The color pattern of the adult *M. costaricensis* and *cherriei* is unknown.)

General remarks.—*Macrogeomys* requires comparison with only two genera, *Heterogeomys* and *Orthogeomys*, from both of which it may be distinguished at a glance, whether viewed from above or below. The most striking points of difference are the remarkably short and broad palatopterygoids and the strongly developed postorbital processes.

KEY TO SPECIES OF MACROGEOMYS.

Audital bulla normal, outer side not flattened.
  Skull short and broad; zygomata divergent anteriorly .... *heterodus*.
  Skull long and narrow; zygomata parallel .... *dolichocephalus*.
Audital bulla peculiar, the outer side flattened and disk-shaped.
  Jugal normal, entering largely into zygoma .... *cherriei*.
  Jugal small, the zygoma complete above without it .... *costaricensis*

MACROGEOMYS HETERODUS (Peters).

(Pl. 11, fig. 2; pl. 14, fig. 3).

Geomys heterodus Peters, Monatsber. K. Preuss. Akad. Wiss., Berlin (1864), 1865, 177.
(Translation of original description appended to present article, p. 189.)

Type locality.—COSTA RICA. Exact locality unknown.

Geographic distribution.—The Irazu range and perhaps other parts of Costa Rica.

General characters.—Size large; face of upper incisors deeply unisulcate, the sulcus narrow and wholly on inner side of median line; enamel face of incisors orange; naked nasal pad large; tail absolutely naked; hind feet naked, with a few stiff hairs about the toes; fore feet nearly naked (shorter than hind); pelage moderately coarse, but not hispid as in *G. hispidus*; no external ears. Coloration peculiar, the muzzle and sides, including sides of rump, being conspicuously paler than rest of upper parts.

Color.—Upper parts uniform sepia or hair brown; muzzle, under parts, and sides all round abruptly much paler, the pale color (a soiled gray) reaching higher on the sides of rump than elsewhere and including base of tail.

Cranial characters.—Skull large, heavy, and rather short; zygomata broadly spreading, their sides divergent anteriorly, maxillary arms sloping backward less strongly than in *dolichocephalus;* antero-external angle well marked, moderately expanded; jugal large and broad, its upper surface not covered by squamosal and maxillary arms; frontal broad and flat, concave along the median line between the orbits and deeply notched on the sides immediately in front of the large postorbital processes, which latter are capped by the apex of the alisphenoid and overlapped posteriorly by the anterior edge of the squamosal. Nasals broadly wedge-shaped and not inflated. The ascending branches of the premaxilla slightly exceed the plane of the orbits. Inferiorly the premaxilla reaches but does not inclose the posterior end of the incisive foramina. The zygomatic breadth is considerably greater than the greatest squamosal or mastoid breadth. The occipital plane is flat (except a vertical median ridge) and slopes moderately forward; the lambdoid crest is straight, slightly incurved near median line. The palatopterygoids are broadly U-shaped and shortly truncate posteriorly, the pterygoids abruptly upturned at right angles to the palatals. The basioccipital has the sides parallel for the anterior half and is broadly wedge-shaped posteriorly. Audital and mastoid bullæ normal. The enamel face of the upper incisors is flat, with the sulcus deep, rather narrow, and wholly on inner side. Traces of the fine inner sulcus may also be seen in the only specimen at hand. The heel of the last upper molar is narrow, much elongated, and slopes strongly outward.

Macrogeomys heterodus differs from *M. dolichocephalus*, the only known species with which it requires comparison, in the very different form of the skull as a whole, it being much shorter and broader, and in the following details: Jugal broadest anteriorly and not covered by squamosal and maxillary arms of zygoma; zygomata divergent anteriorly (instead of parallel); nasals shorter and not inflated; orbital borders of frontal not inflated anteriorly; muzzle and diastema much shorter; palatopterygoids less broad at base; occipital plane broader and lower;

mastoid bullæ narrower vertically. Mandible much shorter. Heel of last upper molar longer and narrower, the outer enamel plate reaching little more than halfway from sulcus to end of heel; in *dolichocephalus* it reaches all the way.

Measurements.—Peters recorded no measurements for his type specimen, but Dr. Matschie has kindly measured it for me and finds the total length 325 mm. He states that the tail is defective. The specimen in the U. S. National Museum, from the Irazu Mountains, which is the subject of the foregoing description (a well-made dry skin), affords the following measurements: Total length, 325; head and body, 280; tail, 65; hind foot with claw, 45; hind foot without claw, 41.

For cranial measurements see Table F, p. 215.

General remarks.—The only species known to me with which *heterodus* needs comparison is *dolichocephalus*, which agrees with it in the abrupt paleness of the muzzle and sides of the rump. But *heterodus* differs from *dolichocephalus* in having the entire under parts and lower sides of the same pale color as the muzzle and sides of the rump. It differs further (in the specimens at hand) in the tint of the upper parts, which is sepia or hair brown instead of chocolate brown, and in the cranial characters above pointed out.

Unfortunately, Peters's description of his *G. heterodus* from Costa Rica is brief and unaccompanied by measurements, cranial characters, or exact locality (see next page). That his animal is the same as *hispidus* of LeConte (from Vera Cruz), as assumed by Coues and Alston, is exceedingly improbable on geographic grounds (in view of the remarkably restricted ranges of all the tropical American species now known) and impossible in view of the wide difference in coloration. Peters described *heterodus* as *bicolor*, the upper parts "dark brown," the muzzle, rump, and underparts "brownish gray or white." *Hispidus* is *concolor* and uniformly dark. Fortunately the type of Peters's *heterodus* is extant. It is still in the Berlin Museum, and Dr. Paul Matschie of that museum has had the kindness to send me additional notes, accompanied by full cranial measurements, which suffice to place its identity beyond question.

Through the courtesy of Mr. F. W. True, Curator of Mammals in the United States National Museum, I have been able to examine several specimens of the *Geomyidæ* from Costa Rica and Guatemala. Among those from Costa Rica is one which agrees in every way with Peters's original description of *heterodus*, and also with the additional particulars concerning Peters's type specimen kindly furnished me by Dr. Matschie. This specimen was recently presented to the museum by the Costa Rica Government through its commissioners to the World's Columbian Exposition at Chicago in 1893. It consists of a well-prepared skin, from which Mr. True has kindly had the skull extracted. It is the only specimen of *heterodus* I have seen, and is the subject of the foregoing description. Mr. George K. Cherrie, of the Costa Rica

National Museum, in response to a letter of inquiry, contributes the following important statement respecting this specimen: "It is No. 313 of the collection of the 'Museo Nacional,' an adult male; was collected October 15, 1890, near Rancho Redondo, a point on the Irazu range between the volcanoes Irazu and Barba, at an altitude of about 1,400 meters. The specimen was purchased from a 'peon' and mounted by myself. October is the last month of the rainy season, and the month in which it rains hardest. I might also add that the species is abundant in the locality given above."

Peters's original description of *heterodus* is as follows: "Our museum has received through Dr. Hoffmann and Dr. v. Frantzius the skin with the perfect skull of a new species of *Geomys* from Costa Rica, whereby the geographical distribution of this genus in Central America is established. This species agrees best with *G. mexicanus* Licht. in size, proportion of the limbs, nakedness of the tail, and the nature of its hairy covering, which latter, however, appears to be somewhat shorter and stiffer. The color is dark brown except on the belly, rump, and muzzle, which are brownish gray or white. It is, however, readily distinguished by the position of the deep longitudinal groove of the upper incisors, which does not run along the middle but between the inner and middle thirds of the teeth, for which reason I propose to name the species *Geomys heterodus*." (Monatsber. K. Preuss. Akad. Wiss., Berlin, 1864, 177.)

Dr. Paul Matschie has kindly sent me the following cranial measurements of Peters's type specimen of *heterodus*, which is in the Berlin Museum (No. 2864):

Greatest basal length (condyle to front of premaxilla), 61; basal length (basion to gnathion), 58; basilar length of Hensel (basion to alveolus of incisor), 51.2; greatest breadth across squamosals, 38; least breadth between postglenoid notches, 27.5; least interorbital breadth, 11; breadth across postorbital processes, 15.25; height of cranium above palate, 24; height above basion, 17; length of upper molar series on alveoli, 14; length of diastema, 22.5; length of single mandible (condyle to front of jaw between incisors), 44; breadth across angular processes, 40; distance from condyle to end of angular process, 13; breadth of muzzle just in front of zygoma, 15.

MACROGEOMYS DOLICHOCEPHALUS sp. nov.

(Pl. 5; pl. 10, fig. 7; pl. 13, fig. 19.)

Type from SAN JOSE, COSTA RICA. No. $\frac{8627}{36295}$ ♂ ad. Collected January, 1866, by José C. Zeledon.

Geographic distribution.—Vicinity of San Jose, Costa Rica. Range unknown.

General characters.—Size large. Animal similar to *M. heterodus;* face of upper incisors deeply unisulcate, the sulcus narrow and wholly on inner side of median line (pl. 15, fig. 8); enamel face of incisors orange;

naked nasal pad large;* tail absolutely naked; hind feet naked, with a few stiff hairs about the toes; fore feet nearly naked (shorter than hind); pelage moderately coarse, but not hispid as in *Heterogeomys hispidus;* no external ears. Coloration peculiar, the muzzle and sides of rump conspicuously paler than rest of upper parts, as in *heterodus.*

Color.—Upper parts dull chocolate brown, except muzzle and lower part of rump, which are buffy in conspicuous contrast, but without line of demarkation. (The buffy of the rump surrounds the base of the tail and reaches further anteriorly on the sides than along the middle of the back.) Under parts similar to back but paler, without line of demarkation; wrists and ankles pale. No dark patch around ears.

Cranial characters.—The skull of *Macrogeomys dolichocephalus*, in addition to the generic characters which associate it with *M. heterodus*, is remarkable for its length and narrowness, the zygomatic breadth in an old male (the type specimen) being only 58 percent of the total length (from condyle to point of premaxilla), and the greatest squamosal or mastoid breadth only 57 percent. The opposite extreme is found in the genus *Platygeomys*, in which the corresponding ratios in *P. gymnurus* are 71 and 75.

The zygomata are not only very narrow, but present the appearance of having been drawn out while in a plastic condition. The maxillary arms slope strongly backward and are broadly rounded off without trace of angle or of angular expansion at the usual place, though there is a slight expansion about the middle of the outer side of the arch, encroaching on the orbito-temporal fossa, which it constricts in the middle opposite the large postorbital processes—a step toward the differentiation of these two fossæ from one another. The jugal is broad, short anteriorly, narrower at both ends than in the middle, and is overlapped by the maxillary and squamosal arms of the zygoma, which nearly or quite meet above it. The frontal is grooved medially between the orbits and is somewhat inflated along the margin of the orbits behind the lachrymal bones, in this respect resembling *O grandis* of Thomas, though the inflation is much less extreme. The sides of the frontal are deeply notched immediately in front of the large postorbital processes. The nasals are wedge-shaped as in *heterodus*, but longer and slightly inflated anteriorly; they are broadest near junction of middle and anterior thirds (in the ♂ only). The ascending branches of the premaxilla barely reach the plane of the orbits. Inferiorly the premaxilla reaches the posterior end of, but does not inclose, the incisive foramina, as in *heterodus*. The zygomatic breadth is only a trifle greater than the mastoid breadth. The occipital plane is flat, high, and slopes strongly forward; the lambdoid crest is slightly convex posteriorly. The palatopterygoids are very broad and

*In an alcoholic specimen (No. 1466 U. S. National Museum) the nasal pad or callosity is broad and rather short, not reaching posteriorly behind plane of upper incisors.

short. [In the male skull the pterygoids are broken off; in the female they are abruptly upturned, as in *heterodus*.] The basioccipital has the sides parallel in the anterior half and is broadly wedge-shaped posteriorly. The height of the cranium above the palate is unusually great, and the zygomata do not descend below a plane drawn midway of the height of the skull. The audital bullæ are normal and rather short, plump, and well rounded anteriorly. The brain case seen from above is subcylindric in shape, in which respect it resembles *Orthogeomys*. The nasals end in front of the plane of the zygomatic arches, while the premaxillæ reach the plane of the orbits, causing an unusual elongation of the median part of the frontal in order to articulate with the nasals. The mandible is long and narrow. The enamel face of the upper incisors is flat, the sulcus deep, narrow, and wholly on inner side (fig. 20[1]).

A young female of *M. dolichocephalus* (No. 36820) differs from the old male above described (36295) in the following particulars: The skull as a whole is very much smaller (see table of cranial measurements); nasals very much shorter, flatter, and broadest anteriorly (instead of at junction of middle and anterior thirds); temporal impressions distant (interspace 3 to 4 mm broad); brain case less cylindrical (owing in part to greater depth of constriction running obliquely upward from posterior root of zygoma to occiput, and in part to a slight bulging upward of the middle of the brain case); basioccipital narrower. The top of the skull in profile is not a straight line, the brain case presenting a slight convexity behind the orbits, while the interparietal and occipital crest fall below the plane of the upper surface as a whole. In both sexes the anterior part of the nasals is strongly decurved.

M. dolichocephalus differs markedly from *M. heterodus*, the only species with which it requires comparison, in the general form of the cranium, which is narrow and greatly elongated; in the narrow, drawn-out zygomata, without trace of angular projection or expansion; in the narrower jugal, which is covered above by the anterior and posterior arms of the arch, which meet or nearly meet above it; in having the zygomata parallel (instead of divergent anteriorly); the nasals longer and somewhat inflated anteriorly; the muzzle and diastema much longer; the palatopterygoids broader at base; the occipital plane higher and less broad; the mastoid bullæ much higher vertically; and the mandible much longer.

Measurements (of type specimen, ♂ ad., from dry skin): Total length, about 380 (approximate, as the tail was not wired and is shrunken); head and body, 310; tail, about 75 (approximate only); hind foot, 48; without claw, 45.

Measurement of a young female from Costa Rica, preserved in alcohol (No. $\frac{14666}{36820}$ ♀ yg. ad., U. S. National Museum, collected by José C. Zeledon and received in October, 1884): Total length, 310; tail, 74; hind foot, with claw, 49; without claw, 43; forefoot, with claw, 45; without claw, 33.

For cranial measurements see Table F, p. 215.

General remarks.—Externally *Macrogeomys dolichocephalus* resembles *M. heterodus* in the peculiar paleness of the muzzle and sides of the rump (in strong contrast to the color of the rest of the upper parts), but differs from *heterodus* in not having the lower part of the sides and belly of the same pale tint. On the other hand, the pale color of the rump reaches a little further forward on the dorsal surface. There is a slight difference also in the tint of the upper parts, the color being dull chocolate brown in *dolichocephalus*, while it is sepia or hair brown in *heterodus*. The important cranial differences have been pointed out.

The alcoholic specimen already mentioned (No. 14666) is a female, and although not fully adult, has borne young, as shown by the large pendent nipples. The teats are: pectoral $\frac{1}{1}$, inguinal $\frac{2}{2}=\frac{3}{3}$, as usual in the group. The pectoral pair are situated on the sides immediately behind the fore legs. The inguinal pairs are not *on* the belly at all, but on the *inner side of the thighs* just below and outside of the belly.

The great callosity at the hinder edge of the wrist is made up of two large tubercles resembling kernels of corn placed side by side and covered by common integument.

MACROGEOMYS COSTARICENSIS sp. nov.

(Pl. 11, fig. 3; pl. 13, fig. 23; pl. 14, fig. 10.)

Type from PACUARE, COSTA RICA. No. $\frac{12911}{22551}$ juv. U. S. National Museum. Collected in 1876 by Juan Cooper. (Original No. 96.)

General characters.—Upper incisors with a single deep sulcus wholly on inner side; pelage in type specimen (immature) short and silky, suggesting the fine crinkled pelage of *Didelphis murina;* tail and hind feet naked; a conspicuous naked pad on end of nose.

Color.—Upper parts uniform dark-brown, *not* paler on nose and rump; underparts abruptly whitish. The type and only known specimen has a large symmetrical white spot on top of the head, occupying about three-fourths of the area bounded by the eyes and ears.*

Cranial characters (of immature skull, pl. 11, fig. 3).—Similar in a general way to an immature ♀ skull of *M. dolichocephalus* (No. 36820), from which it differs in the following particulars: Nasals very much broader throughout, particularly posteriorly; space between posterior ends of ascending arms of premaxilla about twice as broad; zygomata standing out more squarely, nearly at right angles to axis of skull, with anterior angle abruptly rounded; jugal narrower; palatopterygoids shorter and broader; basioccipital very much broader and wedge-shaped, its inferior surface not excavated by audital bullæ; audital

*The white crown patch of *costaricensis* was at first believed to be abnormal, alling in the same category with the irregular white blotches frequently found on the throat and sometimes at the base of the tail, in various species of pocket gophers. But the fact that the spot is bilaterally symmetrical, and is repeated in the only specimen known of a closely allied species, *cherriei*, points to its permanence, at least as a mark of the young.

bulla peculiar, compressed, the outer side strongly flattened; more smoothly rounded, somewhat disk-shaped, and separated from the mastoid bulla inferiorly by a distinct groove. The only other known species of the family having a similar audital bulla is *Macrogeomys cherriei* of Allen. Both are known from single specimens only, and both are too young to show all of the characters of the adult. Their specific distinctness will be apparent at a glance at the accompanying cut (fig. 67) showing the differences in the jugals. The palatopterygoids also are different. The palatopterygoids of *M. costaricensis* are shown on pl. 14, fig. 10, but the figure is inaccurate; in the specimen they are shorter and broader, more nearly as in fig. 3 of the same plate. The pterygoids of *cherriei* are broken, but the remaining base shows that they are considerably more slender.

In *M. costaricensis* the jugal is much shorter than the basioccipital (measured from condyle) and is wholly inferior, the maxillary and squamosal roots of the zygoma meeting above it and on its inner side, so that when viewed from the inner side it appears only as a narrow edge with the apex upward (fig. 67, [4]). In position and relations, therefore, it resembles *Zygogeomys trichopus*, though considerably broader than in that species.

FIG. 67.—Zygomatic arches of *Macrogeomys costaricensis* (3 and 4), and *M. cherriei* (1 and 2). 1 and 3 outer side; 2 and 4 inner side.

Measurements.—Type specimen (probably not more than two-thirds grown) from dry skin: Total length, 330; tail (apparently stretched), 100 from point assumed to be over first caudal vertebra, 80 from apparent base; hind foot, 37 (without claw, 33).

For cranial measurements see Table F, p. 215.

General remarks.—This singular species, for the privilege of describing which I am indebted to the courtesy of Mr. F. W. True, Curator of Mammals in the U. S. National Museum, is represented in the collection by an immature specimen only. At first it was supposed to be the young of *M. dolichocephalus*, but comparison of its skull with that of *dolichocephalus* shows numerous points of specific difference, as above mentioned. While the peculiar texture of its pelage may be due in part to immaturity, this explanation fails when applied to the cranial characters which, as described above, are numerous and striking and of such a nature that most of them would be accentuated by age. In external appearance the animal bears a striking resemblance to the young type of *Macrogeomys cherriei*.

MACROGEOMYS CHERRIEI (Allen)

(Pl. 15, fig. 1.)

Geomys cherriei Allen, Bull. Am. Mus. Nat. Hist., V, 337–338, Dec. 16, 1893.

Type from SANTA CLARA, COSTA RICA. No. 664 ♂ im. Museo Nacional de Costa Rica. Collected in October, 1892, by George K. Cherrie.

General characters.—Naked nasal pad large; tail and hind feet naked. Similar to *Macrogeomys costaricensis* in size and coloration, including the white head patch, but differing in important cranial characters.

Color (of type, juv.).—Upper parts very dark plumbeous or sooty brown; under parts abruptly paler, with distinct line of demarkation; top of head between eyes and ears pure white.

Cranial characters (from skull of type, but little more than half grown, pl. 15, fig. 1).—The skull of *M. cherriei* agrees with *Heterogeomys hispidus* in general form, in the widely-separated temporal impressions; the broad and flat frontal, depressed between the orbits; the flat forward-sloping occipital plane; the form of the zygomata; the inflated nasals, and the short and compact under jaw, with short angular processes. But it is so young that one must be cautious in placing much stress on characters that vary with age. It differs from *H. hispidus* and agrees with *M. costaricensis* in the convexity of the anterior part of the roof of the brain case;* in the peculiarly flattened and smoothly rounded audital bullæ, which are separated from the mastoid bullæ by a distinct inferior transverse groove; and in the long heel of the last upper molar. It differs from *costaricensis* in the size, form, and relations of the jugal (as shown in fig. 67), in narrower palatopterygoid lingulæ, and in a narrower gap behind the nasals (between posterior ends of ascending branches of premaxilla). The jugal is large and long, and nearly half of its upper edge enters into the orbital fossa; it is not covered anteriorly by the maxillary arm of the zygoma, and its total length is greater than that of the basioccipital (measured from condyle). In *M. costaricensis* the jugal is much shorter than the basioccipital (measured from condyle), and is completely covered by the maxillary and squamosal arms of the zygoma, which meet above it (fig. 67). It differs further from *costaricensis* in the shape of the horizontal part of the zygomatic arch, which is not strongly convex upward, and lacks the constriction tending toward the separation of the orbital from the temporal fossa. The large orbito-temporal fossæ are broadest across the middle—just where they are narrowest in *costaricensis*.

Measurements.—Hind foot, with claws, 39 mm. (in dry skin). No measurements were recorded from the flesh, and the specimen is far from full grown.

For cranial measurements see Table F, p. 215.

General remarks.—Through the courtesy of Dr. J. A. Allen, Curator of Mammals in the American Museum of Natural History of New

* It is probable that the saddle-shaped frontal of *costaricensis* and *cherriei* is the result of immaturity, since a young skull of *G. trichopus* (No. 50104) shows the same peculiarity, though in less degree.

[...]rk, I have been able to examine the only specimen known of this species. It belongs to the Museo Nacional de Costa-Rica, and was loaned Dr. Allen by Mr. George K. Cherric, who collected it at Santa Clara, Costa Rica, in October, 1892. It is a male, and, like the type of *costaricensis*, is immature. It resembles the latter in having a large pure-white patch on top of the head,* in the large size of the naked nasal pad or callosity, and in the nakedness of the tail and feet. The hind feet are absolutely naked; the forefeet are naked except for the presence of a few long hairs about the toes. The color of the upper parts is somewhat darker than in *costaricensis*. The specimen is so young that some hesitancy is felt in its generic assignment. It may be a *Heterogeomys* instead of a *Macrogeomys*, though this is exceedingly improbable.

Genus ZYGOGEOMYS† nob.

(Pl. 6; pl. 13, fig. 24; pl. 14, fig. 1; pl. 15, fig. 10; pl. 17, fig. 2; pl. 18, fig. 2; pl. 19, fig. 4.)

Type Zygogeomys trichopus sp. nov., from NAHUATZIN, MICHOACAN, MEXICO.

Generic characters.—Upper premolar with four enamel plates, the posterior restricted to lingual third; upper and lower premolars subequal in length; shaft of upper premolar slightly convex forward.

First and second upper molars with two enamel plates each, the posterior failing on outer side. Third upper molar an incomplete double prism; crown much longer than broad; heel well developed, broad, narrowed on outer side only; sulcus on middle of outer side; absent on inner side. *Inner enamel plate* covering two-thirds to three-fourths of inner side of tooth, straight, reaching end of heel posteriorly; *outer enamel plate* covering about half or a little less than half of outer side of tooth, its anterior half bent strongly outward. Interspaces broadly open, the posterior broadest, directed backward, and often forming a sort of everted lip (fig. 27^5).

Upper incisors bisulcate; principal sulcus on inner side of median line; minor sulcus on inner convexity (see fig. 22^1 and pl. 15, fig. 10).

Cranial characters.‡—Cranium as a whole long and narrow, the zygomata not widely spreading, slender, antero-external angle rounded and not expanded; zygomatic arch normally complete without jugal, the

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* The white crown patch of *cherriei* and *costaricensis* was at first believed to be abnormal. But the fact that the spot is bilaterally symmetrical, and is repeated in the only specimen known of *Macrogeomys costaricensis*, which is likewise young, suggests its possible permanence, at least as a mark of immaturity.

† *Zygogeomys*, with reference to the unique character of the zygomata.

‡ Owing to the extreme difficulty of discriminating generic from specific characters in animals presenting such extraordinary cranial variations as the Mexican *Geomyidæ*, it is thought best in descriptions of genera, of which only a single species is known, to record all of the characters that seem entitled to more than specific weight. The generic diagnosis here given, therefore, errs on the side of fullness. The future discovery of additional species will promptly reduce the number of characters.

maxillary and squamosal arms coming in contact above it; jugal rudimentary, inferior and chiefly external; rostrum long and narrow; temporal impressions meeting in a short but well-developed sagittal crest; palatine bones contracted at base of pterygoids; pterygoids vertical lamellæ as in *Thomomys*, meeting or nearly meeting in median line behind palate. Premaxilla not inclosing incisive foramina, which is bordered posteriorly by the maxilla.

Mandible rather long and slender, much as in *Geomys bursarius;* orbitosphenoids relatively larger than in any other genus of the family, closing the upper part of the sphenoidal fissure (except a foramen at apex) and ankylosed broadly with the alisphenoid (pl. 17, fig. 2), as in some species of *Thomomys;* sphenoid fossæ correspondingly shortened, reaching only halfway from horizontal part of alisphenoid to base of cribriform plate; mesethmoid quadrangular, much longer than high (pl. 18, fig. 2); endoturbinals collectively subquadrate, but with antero-superior corner rather sharply elongated, projecting into posterior emargination of nasoturbinal; the os planum spreading forward in front of fourth endoturbinal about as far as length of latter (pl. 19, fig. 4).

General remarks.—*Zygogeomys* presents the unique combination of distinctly bisulcate incisors with remarkably short sphenoid fossæ and a type of zygomatic arch heretofore unknown in the whole order Rodentia. It presents further an exceptional degree of coossification of the component elements of the skull. The occipitals, parietals, frontal, ethmoid, squamosals, alisphenoids, maxilla, palatines, and pterygoids are ankylosed together; and the basisphenoid, presphenoid, and orbitosphenoids are ankylosed together. Furthermore, the two resulting complex masses are firmly united by ankylosis of the orbitosphenoids with the alisphenoids. The coossification is sometimes carried even further by the fusion of the anterior and posterior arms of the zygoma, and the union of the premaxilla with the maxilla and nasals. The sutures that remain open are between the basioccipital and basisphenoid; between the frontal on the one hand and the nasals, premaxillaries, and maxillary root of the zygoma on the other; between the maxilla and frontal anteriorly, and maxilla and alisphenoid posteriorly. The result of these extensive ankyloses is that in old age all of the bones of the cranium except the mandible are inseparably bound together—if not directly in every case, then in a roundabout manner. *Zygogeomys* thus occupies an anomalous position in the family.

ZYGOGEOMYS TRICHOPUS sp. nov.

(Pl. 6; pl. 13, fig. 24; pl. 14, fig. 1; pl. 15, fig. 10.)

Type from NAHUATZIN, MICHOACAN, MEXICO. No. 50107 ♂ ad., U. S. National Museum, Department of Agriculture collection. Collected October 11, 1892, by E. W. Nelson (original No. 3571).

Geographic distribution.—The Sierra Madre of Michoacan, from Patzcuaro to Nahuatzin; strictly limited to the pine zone, between the altitudes of 6,800 and 9,500 feet (map 3[5]).

General characters.—Size large; tail rather long, entirely naked from base; a conspicuous naked pad at end of nose; fore feet and claws shorter than hind; upper surfaces of both fore and hind feet densely covered with hair, completely hiding the skin; color very dark. Cranial characters marked; maxillary and squamosal arms of zygoma meeting above the jugal, which is greatly reduced.

Color.—Upper parts varying from dark slate to rich seal-brown, glossy, and finely mixed with a very thin wash of ferruginous, especially on the sides; underparts dark plumbeous washed with fulvous; upper surfaces of hind feet slate-gray, sometimes varying to white; an irregular patch of white on throat. Some specimens lack the ferruginous wash and are glossy slate-black. Some have an almost metallic luster.

*Cranial characters.**—Skull, as a whole, long and narrow; zygomatic arches contracted, slender, not expanded at antero-external angle; complete without jugal, which is much reduced in size, the maxillary and squamosal arms meeting above it†; rostrum and nasals long and narrow; temporal impressions meeting in a short but well-developed sagittal crest; palatine bones contracted at base of pterygoids; pterygoids vertical lamellæ as in *Thomomys;* occipital plane nearly vertical, about twice as broad as high; mastoid bullæ fuller and more rounded posteriorly than in *Geomys;* audital bullæ of moderate size, similar to those of *Geomys bursarius;* premaxilla ending below at middle of incisive foramina (instead of surrounding them, as usual in the family); postpalatal pits rather narrow, elongated and shallow, reaching anterior plane of last molar; mandible rather long and slender, much as in *Geomys bursarius;* angular processes moderate; condylar process rather short; coronoid process long, its tip overhanging front of condyle.

Measurements (taken in flesh).—Type specimen, ♂ ad.: Total length, 346; tail vertebræ, 115; hind foot, 46. Average of three adult males from type locality: Total length, 342.6; tail vertebræ, 111; hind foot, 45.8. Average of seven females from type locality: Total length, 322.7; tail vertebræ, 105.8; hind foot, 42.8.

For cranial measurements see Table C, p. 209.

Specimens examined.—Total number 12, from the following localities in Michoacan, Mexico: Nahuatzin, 10; Patzcuaro, 2.

General remarks.—Mr. Nelson found these remarkable animals pretty generally distributed over the wooded mountain slopes except where the timber is dense. They are most numerous about the borders of small grassy parks and in the more open parts of the forest. In places where the land has been cleared in these mountains they infest the culti-

* Owing to the circumstance that only a single species of this remarkable genus is known, it is unsafe to attempt to discriminate sharply between generic and specific characters. For this reason many of the characters given in the generic description are here repeated.

† In some specimens the union is not quite complete.

vated fields and do considerable damage to the corn, wheat, and potatoes of the Indian farmers.

Genus THOMOMYS Max Wied, 1839.

(Text figs. 31^5, 32^b, and 68-71.)

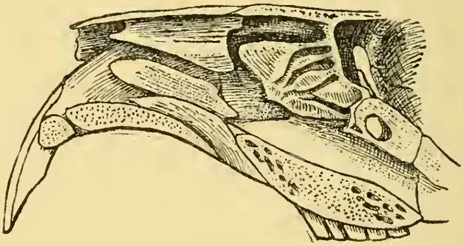
Type *Thomomys rufescens* Max Wied. Type locality unknown.

Thomomys Max Wied, Nova Acta Acad. Caes. Leop.-Carol. Vol. XIX, pt. I., 1839, 377-384.

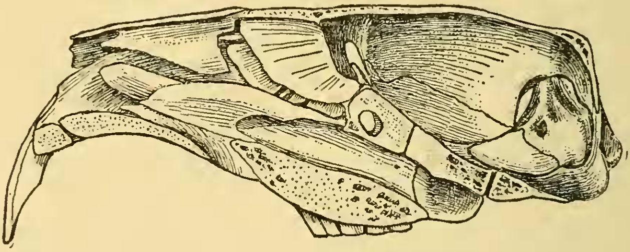
Upper and lower molars, including m^3, with two enamel plates each, one anterior and one posterior (figs. 31^5 and 32^b). Upper incisor with sulcus normally very small and close to inner edge of tooth (fig. 23, p. 72), or absent. In a few species it is relatively large and deep, as in *T. monticola* of Allen.

Orbital plates of frontal not meeting inferiorly behind cribriform plate of ethmoid, but broadly separated by orbitosphenoids (fig. 71, *fro*).

FIGS. 68-71.—*Thomomys bulbivorus*. ♀ Salem, Oregon.



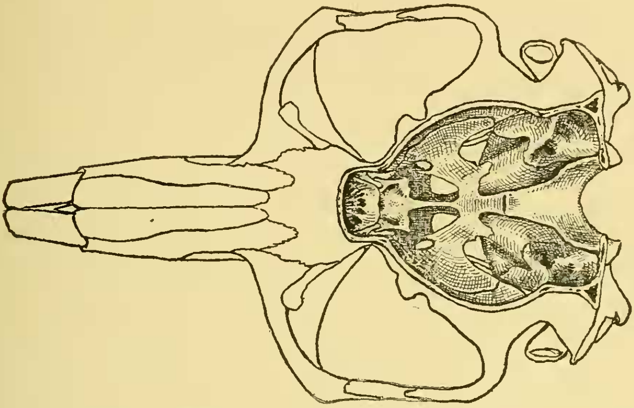
68. Vertical longitudinal section of front of skull, showing turbinated bones. For key see fig. 10.



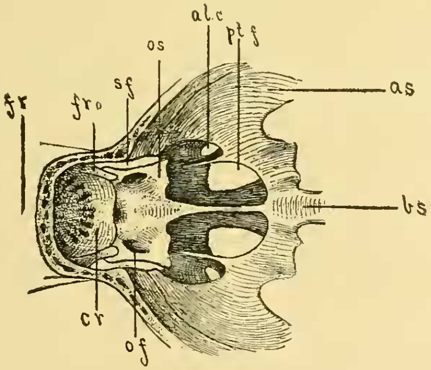
69. Vertical longitudinal median section of skull, mesethmoid and vomer in place. For key see fig. 7.

The accompanying cuts (figs. 68–71) show the relations of the several bones forming the floor of the brain case, and also those of the nasal chamber, in *Thomomys bulbivorus* of Richardson. In this species the incisors project much further forward than usual. The various species differ considerably in important cranial characters, as will be shown in a special paper on the species of *Thomomys*. The geographic distribution of the group as a whole is shown on map 1, A.

Externally *Thomomys* differs from all the other genera of the *Geomyidæ* in the relatively small size of the fore feet. In this respect, and in the faint sulcation of the incisors, the presence of two enamel plates on each of the molars, above and below, and in numerous cranial characters it is much less highly specialized than most members of the family.



70. *Thomomys bulbivorus*, from Salem, Oregon. Skull from above; vault of cranium sawed off to show floor of brain case. For key see fig. 9.



71. Anterior part of floor of brain case. much enlarged. (Same specimen as fig. 70.)
alc Anterior opening of alisphenoid canal.
as Alisphenoid bone.
bs Basisphenoid.
cr Cribriform plate of ethmoid.
fr Frontal.
fro Orbital or descending plate of frontal. It should be observed that this plate does not meet its fellow inferiorly behind the cribriform plate as in most of the other genera.
of Optic foramen.
os Orbitosphenoid.
ptf Pterygoid fossa.
sf Upper part of sphenoidal fissure.

APPENDIX.

(A) Status of Geomys mexicanus Auct.

The earliest description that I have seen of any member of the family *Geomyidæ* was published by Fernandez in 1651, and relates to a Mexican animal called by him the Tucan or Indian mole.* Nearly a century and a half later Kerr bestowed the name *Sorex mexicanus* upon Fernandez's Tucan without having seen a specimen (Kerr, Animal Kingdom, 1792, 207–208). It is not surprising that Kerr followed Fernandez and Buffon in placing the animal among the moles,† misled by its projecting incisors and habit of throwing up little mounds of earth along the course of its subterranean galleries.

The animal seems to have been first referred to the genus *Geomys* by LeConte in 1852 (Proc. Phila. Acad. Nat. Sciences, 1852, p. 160).

In 1827 Lichtenstein described, under the name *Ascomys mexicanus*, three specimens of pocket gophers collected by Deppe on the tableland of Mexico, but the exact locality whence they came is unknown (Brants Muizen, 1827, 27–31). The specimens differed greatly among themselves in color, as originally described by Lichtenstein, and their cranial measurements, kindly furnished me by Dr. Matschie, show that they belong to at least two different genera. The case as it stands, therefore, seems to be as follows: Lichtenstien's *mexicanus* is composite‡

*Following is a translation of the original description: "On the Tucan, or a certain kind of Indian mole. Chap. XXIV. [The Tucan] is apparently a species of mole 9 inches in length, and equaling the humerus of man in size; it is fleshy, fat, and furnished with such short legs that it almost touches the ground with its belly; hair, fulvous; tail, short; claws and nails, long; snout, murine; ears, small and round; front [teeth], two above and same in number below, considerably exserted and curved inward; [the other teeth], though much smaller, are very strong. When fat the flesh is edible, of pleasant taste, but causes stupor. * * *."—(Francisco Fernandez, Historiæ Animalium et Mineralium Novæ Hispaniæ, Liber I, 1651, pp. 7–8.)

†All the American moles were at that time placed with the shrews in the genus *Sorex*, the genera *Scalops*, *Scapanus*, and *Condylura* not having been proposed until sometime later.

‡From the cranial measurements kindly furnished me by Dr. Matschie, and now for the first time published, it is evident that one of Lichtenstein's specimens was a *Platygeomys* closely related to, if not identical with, the animal here described as *P. planiceps*.

and is preoccupied by *mexicanus* of Kerr (1792). The latter is unidentifiable, the vague description applying equally well to several species. It being clearly impossible to use the name *mexicanus*, it should be dropped from the group.

Cranial measurements of two of Lichtenstein's type specimens of Ascomys mexicanus.

[Measured by Dr. Paul Matschie.]

	1558.	1559.
Greatest basal length (condyle to front of premaxilla)	....	55
Basal length (basion to gnathion)	....	52
Basilar length of Hensel (basion to alveolus of incisor)	....	48
Greatest zygomatic breadth	....	35.5
Greatest breadth posteriorly across squamosals	....	40
Least breadth between postglenoid notches	....	28
Least interorbital breadth	....	9.5
Height of cranium above palate	....	20
Height of cranium above basion	....	17
Length of upper molar series on alveoli	14.5	13
Length of diastema	25.5	21
Length of single mandible without teeth	42.5	36
Breadth across angular processes	54	37
Distance from condyle to end of angular process	20	16
Breadth across muzzle just in front of zygoma	13	11

(B.) Tables of Average Measurements of the Various Species.

Average measurements of the species of Geomys.

[All measurements are in millimeters and from fresh specimens.]

Name of species.	Locality.	Number of specimens.			Total length.		Tail vertebræ.		Hind foot.	
		Total.	♂	♀	♂	♀	♂	♀	♂	♀
G. bursarius	Southeastern North Dakota	16	6	10	296	265	90	78	37	34
	Elk River, Minnesota	40	20	20	284	243	......	......	......	......
	Hunter and Williamsville, Missouri	12	4	8	256	223	74	63	33	30
G. lutescens	Western Nebraska*	22	12	10	270	246	84	72	33.5	31.5
	Childress, Texas	10	4	6	257	228	81.5	68	30	28
G. breviceps	Mer Rouge, Louisiana*	38	15	23	231	213	70	61	28	26.5
	Benton, Arkansas	7	4	3	243	206	74	66.3	29	27
	Fort Gibson, Indian Territory	14	5	9	233	209	68.2	61.7	27.8	26.3
	Mineola, Texas	14	6	8	220.5	193.2	67.8	57.2	26.3	24.1
	Melano, Texas	11	5	6	216.2	206	63.8	60.3	26.4	24.5
G. sagittalis	Galveston Bay, Texas*	20	5	15	220	196	64	54	26	23
	Houston, Texas	9	5	4	226	208	64	57	25	24
G. attwateri	Rockport, Aransas County, Texas*	17	10	7	255	220	80	68	30	28
G. texensis	Mason, Texas*	28	....	....	(†)	......	......	......	......	......
G. arenarius	El Paso, Texas*	32	8	24	260	‡250	83	‡78	32	‡32
G. personatus	Padre Island, Texas*	13	4	9	315	293	111	100	40	36
G. fallax	South side Nueces Bay, Corpus Christi, Texas*	13	9	10	263	236	87	75	34	31
G. tuza	Augusta, Georgia*	19	10	9	269	249	89.5	82	34.4	32
	Butler, Georgia§	10	5	5	257	241	82	74	33.8	30.6
G. mobilensis	Mobile Bay, Alabama*	8	4	4	250	229	81	76	33.6	30.5
G. floridanus	San Mateo, Florida	6	3	3	288	235	94	77	35.5	33

* *Type locality.*

† Average of 28 specimens of both sexes: total length, 210; hind foot, 28.

‡ Some of the specimens of *arenarius* recorded as females are very large and were probably males; hence the averages here given for females are probably too great.

§ The specimens from Butler, Ga., are clearly intermediate between *tuza* and *mobilensis*.

Average measurements of the species of Cratogeomys.

[All measurements are in millimeters and from fresh specimens.]

Name of species.	Locality.	Number of specimens. Total.	♂	♀	Total length. ♂	♀	Tail vertebræ. ♂	♀	Hind foot. ♂	♀
C. merriami	Valley of Mexico, Mexico	18	11	7	380	344	113	105	50	46
	Atlixco, Mexico	7	4	3	328	289	94.5	85	47	43.5
	Irolo, Hidalgo, Mexico	3	....	3	.....	324	......	91	......	42.6
C. perotensis	Cofre de Perote, Mexico	12	....	12	.....	310	......	88	......	41.5
C. estor	Las Vigas, Mexico	8	4	4	313	277	89	75	42	37
C. oreocetes	Mount Popocatapetl, Mexico	1	....	1	.....	318	......	92	......	43
C. peregrinus	Mount Iztaccihuatl, Mexico	1	....	1	.....	304	......	87	......	42
C. castanops	Las Animas, Colorado	4	1	3	295	256	95	77	37	33
	Albuquerque, New Mexico	3	....	3	.....	259	......	77	......	34
	Eagle Pass, Texas	....	....	....	.....	.....	......	......	......	......
C. castanops goldmani	Cañitas, Zacatecas, Mexico	3	....	3	.....	257	......	82.7	......	34.3
C. fulvescens	Chalchicomula, Puebla, Mexico	9	3	6	327	302	105	97	43	39.6

Average measurements of the species of Platygeomys, Orthogeomys, Heterogeomys, Pappogeomys, and Zygogeomys.

[All measurements are in millimeters and from fresh specimens.]

Name of species.	Locality.	Number of specimens. Total.	♂	♀	Total length. ♂	♀	Tail vertebræ. ♂	♀	Hind foot. ♂	♀
Platygeomys gymnurus.	Zapotlan, Jalisco, Mexico	6	3	3	353	341	105	9[illegible]	53.5	49.5
	Sierra Nevada de Colima, Jalisco, Mexico.	2	....	2	......	322	......	85	......	49
P. tylorhinus	Tula, Hidalgo, Mexico	3	1	2	345	298	100	91.5	45	39.5
	Patzcuaro, Michoacan, Mexico.	5	3	2	348	331.5	101.5	91.5	49.5	45.5
P. planiceps	N. slope Volc. Toluca, Mexico, Mexico.	3	1	2	372	336.5	121	100	46	43
P. fumosus	Colima City, Mexico	10	7	3	287.5	277	82	75	42	39 5
Orthogeomys scalops	Cerro San Felipe, Oaxaca, Mexico.	10	2	8	369	360	103.5	109	50	50
Orthogeomys nelsoni	Mount Zempoaltepec, Oaxaca, Mexico.	3	2	1	416	380	131	118	54	52
Heterogeomys hispidus.	Jico, Vera Cruz, Mexico	5	2	3	345	311	92	85	53	47
H. torridus	Motzorongo, Vera Cruz, Mexico.	14	4	10	348	317	96.5	81.5	49	45.5
	Chichicaxtle, Vera Cruz (type), Mexico.	1	....	1	......	323	......	88	......	52
Pappogeomys bulleri	Sierra Nevada de Colima, Jalisco, Mexico.	6	2	4	236	216	81	72	33	30
Pappogeomys albinasus.	Guadalajara, Jalisco	1	....	1	......	226	......	68	......	31
Zygogeomys trichopus	Nahuatzin, Michoacan	10	3	7	343	323	111	106	46	43

(C.) Tables of Cranial Measurements.

Table A.—*Cranial measurements of Geomys bursarius, lutescens, breviceps, sagittalis, and attwateri.*

[All measnrements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to gnathion).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals.	Breadth at postglenoid notch.	Interorbital breadth.	Height of cranium above palate.	Height of cranium above basion.	Upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible without teeth.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		Geomys bursarius.																Per ct.	Per ct.	Per ct.
49185	♂ ad	Portland, North Dakota	60	57	53.5	36	31.5	22	6.5	20	16	9.5	24.5	40	38	14	11	63.1	55.2	35
2766*	♂ old	Knoxville, Iowa	59.5	57	53	37.5	34	23.5	7	21	17.5	10	24	40	41.5	15	11	65.8	59.6	36.8
2625*	♂ ad	do	59	57	52.5	36	33	21	7	20	16	10	22.5	39.5	37	14	11	63.1	57.9	35
2772*	♂ ad	do	59	56.5	52	37.5	34.5	22	7	21	17	10	24	40	39.5	15	11	66.3	61	37.1
2624*	♂ ad	do	58	55.5	51	38	33.5	23.5	7.5	20.5	17	9.5	23	39.5	40	15	12	......	......	......
4119*	♂ ad	Ortonville, Minnesota	58	5[illegible]	51	36	32	22.5	7	20	16	10	23	39.5	37	14.5	10.5	......	......	......
2621*	♂ ad	Knoxville, Iowa	54.5	51.5	48	33.5	30.5	20.5	6.5	18	16	9.5	22	36	33.5	11.5	10.5	......	......	......
2925*	♂ ad	Elk River, Minnesota	53.5	51	47	32	28.5	19.5	6.5	19	15	9.5	21.5	36	34	12.5	10.5	......	......	......
2930*	♂ ad	do	53.5	51.5	47.5	32	29	19	6.5	18.5	15.5	9	21.5	36.5	32	11.5	10	......	......	......
2024*	♀ ad	Knoxville, Iowa	50	47	43	30	29	21	7	17.5	14.5	8.5	19	33.5	30	11	10	......	......	......
2623*	♀ ad	do	48	45.5	42.5	28	27	19	6	17.5	14	9	18.5	33	27.5	10	10	......	......	......
2768*	♀ ad	do	47	44.5	41	28.5	26	19	7	16.5	13.5	8.5	16.5	32	28	10.5	9	......	......	......
2771*	♀ ad	do	45	42.5	39.5	27.5	26	19	6.5	16.5	13.5	8	18	30	29	10	9	......	......	......
		Geomys lutescens.																		
25471	♂ ad	Cherry County, Nebraska	50	48.5	44	32.5	27.5	20.5	7	18	13.5	8.5	19.5	33.5	32	12	10.5	67	56.6	37.1
25634	♂ ad	Chadron, Nebraska	47	44.5	40.5	32	27	20.5	7	17.5	13	9	18	32	29.5	10.5	10.5	71.9	60.6	39.3
25472	♂ ad	Myrtle, Nebraska	49	47	42	33	27.5	20	6.5	18	15	8.5	18	32.5	31	11.5	10.5	70	58.5	38.3
23799	♂ ad	Cherry County, Nebraska	48	46	42	31	28	20	6.5	18	13.5	9	17.5	33.5	29	10.5	11	67.3	60.8	39.1
25640	♂ ad	Kennedy, Nebraska	46	43	39	31	26	19.5	6	16	13	9.5	15.5	30	31	10	10	......	......	......
48468	♀ ad	Calloway, Nebraska	47.5	45	41	30.5	26.5	19.5	7	17	13.5	9	17	31.5	29.5	10.5	10.5	......	......	......
56088	♂ ad	Crawford, Nebraska	47	44.5	40.5	30	26	19	7	16.5	13	8.5	17	31.5	29	10	10	......	......	......
25643	♂ ad	Valentine, Nebraska	47	45	41	30	27.5	19.5	7	17	13.5	8.5	17	31.5	29	10	10	......	......	......
48467	♀ ad	Calloway, Nebraask	46	44	39.5	30.5	27	20	7	17	13.5	8.5	16.5	30	30	10.5	10.5	......	......	......

47374	♀ ad.	Las Animas, Colorado	45	43	39	30	27	20	6.5	16.5	13.5	8	16.5	31	28	10.5	9.5	......	......	......
23595	♀ ad.	Cherry County, Nebraska (*type*)	45.5	43	39	28.5	26.5	19	7	17	13	9	16.5	30.5	27	10	11	......	......	......
		Geomys breviceps.																		
46664	♂ ad.	Mer Rouge, Louisiana	46	44	40.5	28.5	25.5	19	7	15.5	12.5	9.5	16.5	31	29	10	8.5	64.7	57.9	35.2
46673	♂ ad.	do	46	43.5	40	29.5	28	19.5	7	16	13	9.5	16.5	31	30	10	10	67.8	64.3	36.7
46356	♂ ad.	do	44.5	42.5	39	29	25	19	6.5	15.5	12.5	9	16	35	29	10	9.5	68.2	58.8	36.4
46663	♂ ad.	do	43.5	42	38	28.5	25	19	6.5	15.5	12	9	16	29	29.5	10	9	67.8	59.5	36.9
46661	♂ ad.	do	43.5	41.5	37.5	27	23	19	7	15.5	12	8.5	15.5	29	28	10	9	......	......	......
46665	♂ ad.	do	42.5	40	36.5	27	23.5	18	7	15	12	8.5	15.5	28.5	27	9	8.5	......	......	......
46666	♂ ad.	do	42	40	36.5	26.5	24	18	6	15	12.5	8.5	15	28	26	8.5	8.5	......	......	......
46363	♂ ad.	do	42	40	36.5	27	24	18.5	7	15.5	12	8	15	28.5	27.5	9.5	9	......	......	......
46659	♀ ad.	do	40.5	38	35	26	23	18	6.5	14.5	12	8	14	27	23	8	8	......	......	......
46657	♀ ad.	do	39.5	37	34	24	22.5	17.5	6.5	14	11	8.5	13	26.5	24	8	8.5	......	......	......
46682	♂ old.	Fort Gibson, Indian Territory	44.5	42	38	28.5	24.5	18	6.5	16	12.5	8.5	16	30	28.5	10	9	......	......	......
		Geomys sagittalis.																		
44957	♂ ad.	Galveston Bay, Texas (*type*)	41	39	36	27.5	23.5	18.5	6	16	12.5	8.5	15.5	28.5	27	8	9	70.5	60.2	41
		Geomys attwateri.																		
119†	♂ old.	Rockport, Texas	49.5	47	43.5	33.5	29	21	7	18.5	14.5	9	20	34.5	35.5	13.5	10	71.2	61.7	39.3
100†	♂ old.	do	49	47	43.5	31.5	27	21	6.5	18	13.5	8.5	19	34	33	12	10	67.8	57.5	38.3
44392	♂ ad.	Tallys Island, Texas	44	42	38.5	28.5	25	18.5	7	16.5	13	8.5	17	30	28	10	10	67.8	59.5	39.2
44321	♂ ad.	Rockport, Texas	44	......	......	[28]	25.5	18.5	6.5	16	13	9	16	30.5	27	10	9	......	......	......
51382	♂ ad.	Rockport, Texas (*type*)	42.5	40.5	38	27.5	24	18	7	16	12.5	8	16	30	27	10	9	67.8	59.2	39.5
44316	♀ ad.	Matagorda, Texas	40	38	35	25	22.5	18	6	14.5	12	8	14.5	28	......	8	8.5	65.7	59.2	38.1
51497	♀ ad.	Rockport, Texas	38	36	33.5	24.5	21.5	18	7	14.5	11.5	8	13	......	......	......	9	68.0	59.8	40.2
44222	♀ ad.	Matagorda, Texas	40	38	35	26.5	23.5	18.5	6.5	15	12	8	14.5	25.5	......	9	8.5	......	......	......
44317	♀ ad.	do	39.5	38	35	25	22.5	18	6	15	11.5	8	15	27.5	25	9	9	......	......	......

* Merriam collection. † Collection of H. P. Attwater.

TABLE B.—*Cranial measurements of Geomys personatus, fallax, texensis, and arenarius.*

[All measurements are in millimeters. Museum numbers refer to U. S National Museum unless contrary is stated.]

Museum No.	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to front of premaxilla).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals (over mastoids).	Breadth at postglenoid notch.	Interorbital breadth.	Greatest height of cranium above palate.	Greatest height of cranium above inferior lip of foramen magnum.	Length of upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		Geomys personatus.																Perct.	Perct.	Perct.
43294	♂ ad	Padre Island, Texas	56	53.5	49.5	36	33	24.5	7	20	16	11.5	21	38.5	36	14	12	67.2	61.6	37.3
43432	♂ ad	do	56	53.5	49	35.5	33	24	6.5	19.5	15	10	21	38.5	34	13	10.5	66.3	61.6	36.4
43434	♂ ad	do	54	51.5	47	34.5	32.5	23	6	18.5	15.5	11.5	19	37	34.5	13.5	11	66.9	63.1	35.9
43430	♂ yg. ad	do	53.5	51	47	33	30.5	23	6.5	18.5	15	10.5	18.5	37	33	12.5	11	64.7	59.8	36.2
43436	♀ ad	do	53	50	46	31.5	29	21	7	18.5	14.5	10	19	35.5	36.5	12	10.5	......	......	......
43429	♀ ad	do	51	48.5	45	31.5	28	22	7.5	18.5	15	10.5	18	35	31.5	12	11	......	......	......
43438	♀ ad	do	51.5	49	45.5	31.5	28.5	21.5	7.5	18.5	15	10	18.5	35	32	12.5	10.5	......	......	......
43433	♀ ad	do	51	48.5	44.5	31	29	22.5	7.5	18	14	10	18	34	31	11.5	11.5	......	......	......
43435	♀ ad	do	49	46.5	42	31.5	30	22	6.5	17.5	14.5	11	16.5	34.5	......	12	10.5	......	......	......
		Geomys fallax.																		
43840	♂ ad	South side Nueces Bay, Texas	46	43.5	40	28	27	20	6	17	13.5	9	16	32	30	10.5	9	64.3	62	39
43845	♂ ad	do (type)	45.5	43.5	39.5	30	27.5	20	6.5	16.5	14	8.5	17	31	31.5	11.5	8.5	68.9	63.3	37.9
43259	♂ ad	do	45	42	39	27.5	25.5	19.5	6.5	16.5	13.5	9	16	30	28	10	9	65.4	60.7	39.2
43843	♂ ad	do	45	42	39	27.5	27	20.5	6	16	13	9	15.5	31	30	11	8.5	65.4	64.2	38
43262	♂ yg. ad	do	45	42.5	39	27.5	26	20.5	6.5	17	13	9	15.5	30	28	10.5	9	......	......	......
43842	♀ ad	do	42	39.5	36	26	24	19.5	7	16	13.5	8.5	15	29	26	9	8.5	......	......	......
43841	♀ ad	do	42	39.5	36	25	24.5	19.5	6.5	16	13	8.5	14.5	28.5	25.5	9.5	8.5	......	......	......
43292	♀ ad	do	41.5	39.5	36	26.5	24.5	20	6.5	16	13	8.5	14.5	28.5	28	10	9	......	......	......
43844	♀ ad	do	40.5	38.5	35	25	23.5	18	6.5	15.5	12.5	8	14	28	26	9.5	8.5	......	......	......
43293	♀ ad	do	40.5	38	35	25	23	18.5	6	15.5	12.5	8.5	13.5	27	25.5	9.5	8.5	......	......	......
		Geomys texensis.																		
4161*	♂ ad	Mason, Texas	42.5	40.5	37	27	24.5	19	6.5	16	12	8	15.5	......	......	......	9.5	66.6	60.4	39.5
4164*	♂ ad	do	39.5	37.5	34	24	22	17.5	5.5	14.5	12	8	14	26	26	9	8.5	59.2	54.3	38.6

2415*	♂ ad	do	39.5	37.5	34	24.5	22	17.5	6.5	14.5	12	8	14	......	......	......	8.5	65.3	58.6	38.6
4163*	♂ ad	do	39.5	37	34	23.5	21	17	6	14.5	11.5	8	13.5	26	24.5	7.5	8.5	63.5	56.7	39.1
2694*	♀ ad	do	38	35.5	32	22.5	22	17.5	7	14.5	11.5	7.5	12.5	25.5	23	8	8	......	......	......
4172*	♂ ad	do	39	37	33	25	22	17.5	6.5	15	11	8.5	12.5	26	26	8.5	9	......	......	......
2259*	♀ ad	do (type)	37.5	35	32	23	20.5	17	6	14	11.5	7.5	12.5	25	24	7.5	8	......	......	......
		Geomys arenarius.																		
25015	♂ ad	El Paso, Texas (type)	43	40.5	37	27	23.5	18.5	7	16	12	8	15	28.5	26.5	9	9	66.6	58	39.5
58340	♂ old	do	42.5	40.5	37	28	24.5	18.5	6.5	15.5	12	8	15	28	28	9.5	9.5	69.1	60.4	35.8
58334	♂ yg. ad	do	42	40	36.5	25.5	23.5	19	7	15.5	12	8	14.5	28	24.5	9	9	63.7	58.7	38.7
23787	♂ ad	do	42	39.5	36	25.5	23.5	18	6	15.5	11.5	7.5	14.5	28.5	27	9	8.5	64.5	59.4	39.2
58339	♂ ad	do	41.5	39	35.5	25	24.5	19	6.5	15	12	8.5	13.5	28	27	9	9	......	......	......
24973	♀ old	do	41	38.5	35	26	23	17.5	6.5	15.5	10.5	7.5	14.5	27	26.5	9	9	......	......	......
58337	♀ ad	do	41	39	35	25.5	24	18	6	15.5	11.5	8	14	27	26	9	9	......	......	......
55013	♀ ad	do	40.5	38	35	25.5	23	18	6	15	11.5	8	13	27	25	9	9	......	......	......
25016	♀ ad	do	40	37.5	34	24	23	18	6.5	15	11	8	13	27	26	9	8.5	......	......	......

* Merriam collection.

TABLE C.—*Cranial measurements of Geomys tuza, floridanus, mobilensis, and Zygogeomys trichopus.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to front of premaxilla).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals (over mastoids).	Breadth at postglenoid notch.	Interorbital breadth.	Greatest height of cranium above palate.	Greatest height of cranium above inferior lip of foramen magnum.	Length of upper molar series of alveoli.	Length of diastema.	Greatest length of single half of mandible.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		Geomys tuza.																Per ct.	Per ct.	Per ct.
58591	♂ ad	Augusta, Georgia	52.5	50	46	32	28	21	6.5	18.5	13.5	10.5	20.5	37	33.5	12	10	64	56	37
58593	♂ ad	do	52.5	49.5	46	31	28	21	7	19	13	10	20	37	34	12	10	62.6	56.5	38.3
58639	♂ ad	do	51	48	44.5	31.5	26.5	20	7	18.5	13	10	19.5	35	31	11.5	9	65.6	55.2	38.5
63842	♂ ad	do	50	47	44	31.5	26.5	20	7	18	13.5	10	19	35	32	12	10	67	56.4	38.3
58643	♂ ad	do	50	47.5	43.5	29.5	26	19	6.5	17.5	12.5	9.5	19	34	31	11.5	9.5	......	......	......
63844	♂ ad	do	50	47	44	29.5	26	19.5	6	18	13	10	19.5	35	30.5	11	9.5	......	......	......
58594	♂ ad	do	50	47	44	30	26	19.5	7	18	13	10	19.5	35	30	11.5	10	......	......	......
58642	♀ ad	do	47	44	40.5	27	24	19.5	6	16.5	12.5	9.5	17.5	32	27.5	10	9	61.3	54.5	37.5
58595	♀ ad	do	46	43	40	26.5	24	20	6.5	16.5	12.5	9.5	16.5	32.5	27	10	9	......	......	......
58640	♀ ad	do	46	43	39.5	27	24.5	19.5	6.5	17	12.5	10	16	32	27.5	10	9.5	......	......	......
58646	♀ ad	do	44	41	38	27	24	19.5	6.5	16.5	12.5	9.5	15.5	31	25	9.5	8.5	......	......	......
58644	♀ ad	do	44	41.5	37.5	27	24	19	6.5	15.5	12	9.5	15.5	30	27.5	9.5	8.5	......	......	......
58641	♀ ad	do	43	41	38	25,5	23	18.5	6.5	15.5	12	9	15	30	25	9	8.5	......	......	......
		G. tuza floridanus.																		
6514*	♂ ad	San Mateo, Florida	53.5	51	47	31.5	27	20.5	7.5	18	14	10.5	20.5	38	34.5	13	13	61.7	52.9	35.2
6511*	♂ ad	do	52.5	49.5	46.5	31	28	21	7	18	14	11	20.5	37.5	32.5	11.5	10.5	62.6	56.5	36.3
6512*	♂ ad	do	50.5	48	44.5	31	27.5	20	7.5	18	13.5	10.5	21	36.5	32.5	12	10.5	64.5	57.3	37.5
24131	♂ ad	Pomona, Fla	51	49	45	31	27.5	18.5	7	18.5	14	11	20	35	32.5	12	10	63.2	56.1	37.7
51510	♂ ad	Gainesville, Fla	48.5	45.5	42	29	24.5	19	7	17	13	9.5	20	34	30.5	11	9.5	......	......	......
24128	♀ ad	Pomona, Fla	45.5	43	40	27	25	19	7	16.5	13	9.5	17.5	32	28.5	10.5	9	62.8	58.1	38.3
24130	♀	do	42.5	40	37	26.5	23.5	18	7	16.5	13	9.5	15.5	29.5	27.5	9.5	9	......	......	......
		G. tuza mobilensis.																		
46023.	♂ ad	Mobile Bay, Alabama (*type*)	52.5	50	46	33.5	27.5	20.5	9.5	18	13.5	11	22	38	34	12	10	67	55	36
46024	♂ ad	do	51	48.5	45	32	26	19	8	17	13.5	9.5	21	36	32	11	9	65.9	53.5	35

46019	♀ ad	......do	44.5	42	39.5	27.5	23	18	7.5	16.5	12.5	9	17.5	31	......	8.5	8.5	61.8	51.6	37
46021	♀ ad	......do	44	42	38.5	28	24	19	8	16.5	12.5	10	17	32	28.5	9.5	9	66.6	57.1	39.2
46017	♀ ad	......do	43.5	41	38	25.5	22.5	18.5	7	16	12.5	9	16.5	31	26	9	8.5	62.2	54.9	39
		Zygogeomys trichopus.																		
50106	♂ ad	Nahuatzin, Michoacan, Mexico	61	58.5	54	39	35.5	25	9.5	20	17.5	11.5	24.5	42	40	15.5	11.5	66.6	62	34.1
50100	♂ ad	......do	61	58	53.5	38.5	35	25	8.5	21	18	12	23	40	42.5	15	11.5	66.3	60.3	36.2
50107	♂ ad	......do (*type*)	60	56.5	53	37	33.5	25	8	21	18	11	24	40	40	14.5	11.5	65.4	59.2	37.1
50099	♂ ad	......do	59.5	56	52	38.5	33.5	25	8	21	18	12	23	39	40	15	11.5	68.7	59.8	37.5
50105[a]	♀ ad	......do	57	53.5	49.5	35.5	33.5	25	8.5	20.5	16.5	11.5	22	37.5	35	14	11.5	66.3	62.6	38.3
50108	♀ ad	......do	56.5	53.5	49	36	33	25	8	20	17.5	11	21	37.5	37	13.5	10.5	......	......	......
50103	♀ ad	......do	56	53.5	49.5	35.5	34	25.5	8	20	17	11.5	22	37	38	14	10.5	......	......	......
50101	♀ ad	......do	55	52	48	37	32.5	24.5	8	20	16	10.5	21.5	37	36.5	13	11	......	......	......
50102	♀ ad	......do	52.5	49.5	46	34.5	30	23	8	20	15.5	11.5	18.5	35	34	12	10.5	......	......	......
47187	♀ ad	Patzcuaro, Michoacan, Mexico	50	46.5	43	30.5	29	21	8	18.5	15	11.5	18	33	32	11.5	10	......	......	......

[a] Merriam collection.

TABLE D.—*Cranial measurements of the species of Cratogeomys.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to front of premaxilla)	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals (over mastoids).	Breadth at postglenoid notch.	Interorbital breadth.	Greatest height of cranium above palate.	Greatest height of cranium above inferior lip of foramen magnum.	Length of upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		C. merriami.																*Per ct.*	*Per ct.*	*Per ct.*
57970	♂ old	Amecameca, Mexico (giant)	74.5	70.5	64	49	48.5	33.5	9.5	28.5	21	15.5	28.5	52	53	21	17	69.5	68.7	40.4
50110	♂ ad.	Lerma, Mexico	70	66.5	61	47	42	31	9	25	18.5	13	29	47	48.5	17.5	15.5	70.6	63.4	37.5
50112	♂ ad.	Tlalpam, Mexico	68	64.5	58.5	42.5	39	29	8	25.5	19.5	13.5	26.5	45	46.5	17	15.5	65.8	60.4	39.5
51447	♂ ad.	Amecameca, Mexico	67.5	64.5	58.5	45	41.5	30	8.5	27	19.5	13.5	26	46	47	17.5	14.5	69.7	64.3	41.8
51446	♂ ad.	do	67	63	57	45.5	41	31	8.5	26.5	19.5	14	26	45	51	18.5	15	72.1	65	42
51158	♂ ad.	Huitzilac, Mexico	67	64	58.5	44.5	43.5	31.5	9	24.5	19	13.5	25.5	44	50	18.5	14.5	......	......	......
50113	♂ ad.	Tlalpam, Mexico	65.5	62	57	44.5	39.5	31	8.5	24.5	18.5	12.5	26	46	48	17	14.5	......	......	......
55347	♂ ad.	Atlixco, Mexico	64	60	54.5	45	43.5	31	9	25	18	12	25.5	45	51	19.5	15	......	......	......
55346	♂ ad.	do	63	60	54.5	42.5	42	29	9	24	18	12.5	24.5	44	47	17	14	......	......	......
50109	♂ yg. ad.	Salazar, Mexico	61.5	58	53.5	40	39	29	8	23	17	12.5	24	41	43	15.5	14	......	......	......
50114	♀ ad.	Tlalpam, Mexico	60.5	57.5	52.5	41	37	26	7.5	23.5	18	12.5	23	41	43.5	16	13.5	71.3	64.3	40.8
53494	♀ ad.	Irolo, Mexico	60	56.5	51	40.5	38	31	8	23	17	12	22	40	42	15	14.5	......	......	......
53496	♀ ad.	do	59.5	56.5	51	40.5	37.5	30.5	9	23.5	17.5	12	22	40	42	14.5	13.5	......	......	......
53495	♀ ad.	do	59.5	......	......	39.5	38	29.5	7.5	23	17	12	22.5	39.5	41	15	13	......	......	......
55351	♀ ad.	Atlixco, Mexico	57.5	54	49	38	35	26	9	22.5	16.5	11.5	21.5	39	42	15	13	......	......	......
55350	♀ ad.	do	54	51	46.5	35	33	24	8.5	21	15	11.5	19.5	36.5	40	15	12.5	......	......	......
		C. perotensis.																		
54295	♀ ad.	Cofre de Perote, Mexico	58.5	55	50.5	39.5	36	27	7.5	22.5	16.5	12	21	40.5	40.5	15.5	12	71.7	65.3	40.9
54296	♀ ad.	do	58.5	55	51	39	35	28.5	7.5	22.5	17	12	23	40	41	15	12	70.9	63.6	40.9
54291	♀ ad.	do	57	54	49.5	38	34.5	25.5	7.5	22.5	17.5	11.5	21	39	40	14	11.5	70.3	63.8	41.6
54299	♀ ad.	Cofre de Perote, Mexico (*type*)	56.5	54	49.5	38	34	26.5	7	22	17	10.5	21.5	39	42	15.5	11.5	......	......	......
54289	♀ yg. ad.	Cofre de Perote, Mexico	54.5	51.5	47	37	33	25	7.5	21.5	16.5	11	20.5	37.5	37.5	12.5	11.5	......	......	......
		C. estor.																		
54308	♂ ad.	Las Vigas, Vera Cruz, Mexico (*type*)	55	52	47.5	38	33.5	26	8	20.5	16	11	20	37	38.5	13.5	12	73	64.4	39.4

54305	♂	Las Vigas, Vera Cruz	55.5	52	48	38.5	34	26	7.5	21	15.5	11	21	37	37.5	13.5	12	74	65.3	40.3
54307	♂	......do	54.5	52	47.5	38	33.5	26.5	7.5	20.5	15.5	11	20	37.5	38.5	13.5	12.5	73	64.4	39.4
		C. oreocetes (type).																		
57963	♀ yg.ad.	Mount Popocatapetl, Mexico	54.5	51	47	32.5	32	24	8	20	15	10.5	20	36	34	13	12.5	63.7	62.7	39.3
		C. peregrinus (type).																		
57964	♀ old...	Mount Ixtaccihuatl, Mexico	55.5	52	47.5	35	34.5	27.5	7.5	21.5	15	11.5	20	37	35	13	12	65.3	66.3	41.3
		C. castanops.																		
47368	♂ ad....	Las Animas, Colorado	54	51	46.5	38	30.5	23	7	20.5	15.5	10.5	21	36.5	38	14	11	74.5	59.8	40.1
47364	♀ ad....	......do	50	47	43	32.5	28	22	7	19.5	14.5	9.5	19.5	33.5	32.5	12.5	10	69.1	59.5	41.5
47363	♀ ad....	......do	47.5	44	41	31	27	21.5	7.5	18.5	14	10	18	32	31	11.5	10	70.4	61.3	42
47365	♀ ad....	......do	47.5	44.5	40.5	30	26.5	21	6.5	18	13.5	10	18	31.5	31	11	10	......	......	......
25108	♂ ad....	Marfa, Texas	56	53	49	37.5	33.5	22	7	21.5	15.5	9.5	22	38	38	14.5	10.5	......	......	......
51048	♂ ad....	Jaral, Mexico	56.5	53.5	49	......	32.5	24	7.5	20.5	15.5	10.5	22.5	38	......	14	12	......	......	......
51049	♂ yg.ad.	......do	53.5	50.5	47	34	30	22.5	7	20	15	10	21.5	36	36	12.5	11.5	......	......	......
		C. castanops goldmani.																		
57968	♀	Cañitas, Zacatecas, Mexico	49	46	42.5	32	27.5	21.5	7.5	18.5	13.5	9	18.5	32.5	33	11.5	10.5	69.5	59.7	40.2
57965	♀	Cañitas, Zacatecas, Mexico (*type*)	47.5	44.5	41	32.5	29	21	7.5	18	13	9.5	18.5	31	33	12	10.5	73	65.1	40.4
		C. fulvescens.																		
58168	♂ ad....	Chalchicomula, Puebla, Mexico (*type*)	58	55	50.5	40	34	26	7.5	22.5	17	12	22	38	40	14	12.5	72.7	61.8	40.9
58166	♂ yg.ad.	Chalchicomula, Puebla	56	52	48	38.5	33.5	25	8	22	17	12	21	38.5	41	14.5	13	74	64.4	42.3
53497	♀ ad....	......do	54.5	51	47	35.5	30	22.5	7.5	22	16.5	11	20	36.5	36	13	12	69.6	58.8	40.1
53498	♀ ad....	......do	54	51	47	35.5	30.5	24	6.5	20.5	15.5	10.5	20	36.5	36.5	12	11.5	......	......	......
58169	♀ ad....	......do	52	49	45	34	29.5	23	7	21	16	10	19	35	33	12.5	11	......	......	......

TABLE E.—*Cranial measurements of the species of Platygeomys.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number.	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to front of premaxilla).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals (over mastoids).	Breadth at postglenoid notch.	Breadth across postorbital processes.	Interorbital breadth.	Greatest height of cranium above palate.	Greatest height of cranium above inferior lip of foramen magnum.	Length of upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratio to basal length. Zygomatic breadth.	Ratio to basal length. Greatest squamosal breadth.	Ratio to basal length. Greatest height of cranium above palate.
		P. gymnurus.																	Per ct	Per ct	Per ct
45614	♂ ad....	Zapotlan, Jalisco, Mexico (*type*) ..	66	62.5	57.5	45	48	34	......	10	24	20	14	26	43	57.5	21	15	72	76.8	38.4
45611	♂ ad....	Zapotlan, Mexico	66	62	57	47	49.5	35.5	......	9.5	23	19	14.5	25	45	63	23.5	15	75.8	79.8	37
45610	♂ ad....	.....do............................	65.5	62	57.5	46.5	47	33	......	10	24	19	14	25.5	42	56	20	15	75	75.8	38.7
46214	♂ ad....	.....do............................	65	61	56	44.5	47	34	......	10	23	18	14.5	24	41.5	57	20.5	15.5	72.9	77	37.7
45609	♂ ad....	.....do............................	64	60	56	46	46.5	33	......	10	23.5	18.5	14	23.5	42	57	20	15	......	......	......
45613	♂ yg. ad	.....do............................	62.5	59	54.5	44	44.5	30.5	......	9	23	17.5	14	23	41	56	19.5	15	......	......	......
45615	♀ ad....	Sierra Nevada de Colima, Jalisco .	62.5	58.5	53.5	43.5	44.5	32	......	9.5	23	18.5	14.5	22	41.5	49	19	14.5	69.6	74.3	39.3
45616	♀ ad....	.....do............................	60	57	53	42	42.5	31	......	9.5	22	18	13	22.5	42	52	20	14	......	......	......
		P. tylorhinus.																			
51883	♂ ad....	Tula, Hidalgo, Mexico (*type*)......	61.5	58	54.5	43	44	31	......	8	23.5	18.5	12	24.5	42	52	18.5	12.5	88.6	69.9	38.2
51881	♀ ad....	Tula Hidalgo.......................	53	50	47	36	36.5	27	......	7.5	21	15.5	12.5	19	35	42	15	11	88.6	67.9	39.6
51884	♀ im ...	.....do............................	51	48	45	33.5	36	26	......	7.5	20	14.5	10.5	20	34	40.5	13.5	10.5	88.2	65.6	39.2
47183	♂ ad....	Patzcuaro, Michoacan, Mexico....	66	62	57	46	46	32.5	......	9	24.5	19.5	13	25	44	55	19	16	74.2	74.2	39.5
47182	♂ ad....	.....do............................	64.5	60	56	42	44	31	......	9	23.5	17	13	24	43	48	18.5	14	70	73.3	39.1
47181	♀ ad....	.....do............................	61	56.5	52.5	42	44	32	......	8	23	18.5	12	23	40	51	17.5	12.5	74.3	77.8	40.7
47185	♀ ad....	.....do............................	60.5	56.5	53	41.5	44	32	......	7.5	22.5	18	12.5	23	40	50	17	13	......	......	......
47184	♂ yg. ad	.... do............................	59	55	52	40	40.5	28.5	......	7.5	23	16.5	12	23	40	46	17	12	72.7	73.6	41.8
		P. planiceps.																			
55906	♂ ad....	Volcan Toluca, Mexico (*type*)	63	59	55	42.5	43.5	30	......	8	22.5	17.5	13	24	41	51	18	13	72	73.7	38.1
55907	♀ ad....	Volcan Toluca, Mexico	56	52.5	49	38	39.5	28	......	7.5	21	16	12	21	36	46	16	12	72.3	75.2	40

		P. fumosus.																			
45211	♂ ad....	Colima City, Mexico	59	55.5	51	38.5	38.5	30	......	9.5	21	16	13	22	38	46	15.5	13.5	69.3	69.4	37.8
45207	♂ ad....	Colima City, Mexico (*type*).........	56	53	48.5	39	37.5	29.5	......	8.5	20	15.5	12.5	20.5	37	46.5	15.5	13	73.5	70.7	37.7
45213	♂ ad....	Colima City, Mexico..............	54.5	51	47	38.5	36	28.5	......	8.5	20.5	15	12	20.5	37	45	15.5	12.5	75.4	70.5	40.1
45208	♂ ad....	.....do..........................	53.5	50	46.5	37	36	28.5	......	8.5	19	15.5	12	19.5	35.5	44	14.5	12.5	74	72	38
45212	♀ ad....	.....do..........................	52	49.5	45.5	36	36	29	......	8.5	20	15	12	19	35.5	43	14	12.5	72.7	72.7	40.4
45214	♀ ad....	.....do..........................	52	49	45	35.5	34.5	27.5	......	8	19.5	14.5	11.5	19	35.5	40.5	14	11.5	72.4	70.4	39.8
45205	♀ yg. ad	.....do..........................	51.5	49	44.5	35.5	33.5	28	......	8	19	13.5	11.5	18.5	34.5	41.5	14	12.5	72.4	68.3	38.8

TABLE F.—*Cranial measurements of the species of Pappogeomys, Orthogeomys, Macrogeomys, and Heterogeomys.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number.	Sex and age.	Locality.	Greatest basal length (condyle to gnathion).	Basal length (basion to gnathion).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals.	Breadth at postglenoid notch.	Breadth between postorbital processes.	Interorbital breadth.	Height of cranium above palate.	Height of cranium above basion.	Upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible without incisor.	Greatest breath of mandible between angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		Pappogeomys bulleri.																	*Per ct*	*Per ct*	*Per ct*
45622	♂ ad	Sierra Nevada de Colima, Jalisco, Mexico.*	40	38	35	25.5	24	19.5	......	7	16	12.5	9	14	28	26.5	9	8.5	67.1	63.1	42.1
45619	♀ ad	....do	39	36.5	33.5	25	23	19	......	8	15.5	12	9	13.5	27	26	9	8	65.7	60	44.3
45623	♀	....do	37.5	35	32	23	21	18.5	......	7	15.5	12	8.5	13.5	25	24	8	8	65.7	60	44.3
		Pappogeomys albinasus.																			
46215	♀ ad	Guadalajara, Jalisco (*type*)	39 5	36.5	33	25.5	23.5	20.5	......	7.5	15	12	9.5	12.5	25	26.5	9	9	69.8	64.3	41
		Orthogeomys scalops.																			
67029	♂	Cerro San Felipe, Oaxaca	67.5	64	59.5	42	40	27	16.5	14	25.5	19.5	14	25	45	43.5	16	14	65.6	62.5	39.8
67030	♂	....do	67	63	57.5	41.5	42	28.5	18.5	15	26.5	20.5	13	26	46.5	42.5	16	14	65.8	66.6	42
65973	♀	....do	67	63.5	58	37	40	27.5	17	15	25.5	19.5	14.5	25	45.5	43.5	16	13	58.2	62.9	40.1
67033	♀	....do	66	62	57	38	41	28	18	15	26	20	14	24.5	44.5	40.5	15 5	14.5	......	......	......
67026	♀	....do	64.5	60.5	55.5	37.5	40	29	18.5	16	25	19	14	23	43.5	38	14.5	14.5	......	......	......
79.1.6.2.†	....	Tehuantepec (*type*)‡	......	63	56.7	40.8	39	26.7	16.2	14.2	......	18.4	......	24.5	......	......	......	15	......	......	......
		Orthogeomys grandis.																			
65.5.18.65.†	ad	Dueñas, Guatemala (*type*)‡	72	68	62	43.8	44.2	30	16	15	29	20.5	16.5	25.5	51	49	19.6	16.2	64.4	65	42.6
		Orthogeomys nelsoni.																			
66753	♂	Near Totontepec, Oaxaca	75	70	64	45	44	29.5	18	17	28.5	22	15	28	51	48.5	17	17.5	64.2	62.8	40.7
66751	♂	Mount Zempoaltepec, Oaxaca, Mexico (*type*).	73	70	64	44	42.5	30.5	18	16	28	21.5	15	28.5	50	47	17	16	62.8	60.7	40

66752	♀	.... do	68	63.5	58	39	39.5	28	17	14	24.5	19.5	14	25.5	46.5	40	16	15	61.4	62.2	38.5
		Macrogeomys heterodus.																			
2864¶	....	Costa Rica (*type*)§	61	58	51.2	......	38	27.5	15.25	11	24	17	14	22.5	44	40	13	15	......	65.5	41.3
W. F. 3	♂ ad	Irazu Range, Costa Rica	64	60	55	42.5	40	30	18	10	25.5	19.5	15	24	45	44	17	15	70.8	66.6	42.5
		Macrogeomys dolichocephalus.																			
36295	[♂ ad] ..	San Jose, Costa Rica (*type*) .	69	65	60	40.5	39.5	29	17	9.5	26.5	19	15.5	27.5	48.5	42	17	15.5	62.3	60.7	40.7
36820	♀ im	.....do	56	52	48	33	33	24.5	16	9.5	23	17	13	20.5	38.5	36	14	13.5	63.4	63.4	44.2
		Macrogeomys costaricensis.																			
22551	im	Pacuare, Costa Rica (*type*) ..	52	48.5	44.5	33	29.5	23	15.5	9	21.5	16	13	20	37	35	12.5	14	68	60.8	44.3
		M. cherriei.																			
C. R. N. M. 664	im	Santa Clara, Costa Rica (*type*).	51	47.5	44	34	30	23.5	15	9.5	21.5	16	12	20	37	(?34)	12.5	13	71.5	63.1	45.2
		Heterogeomys hispidus.																			
55016	♂	Jico, Vera Cruz, Mexico	......	......	......	45	42.5	30.5	14.5	11	25.5	19.5	14	......	42	48.5	18	......	......	......	......
55343	♂	.....do	61	57.5	53	38	39.5	28.5	15	11.5	24.5	17	13.5	22	40	43.5	16	14	66	69.6	42.6
55060	....	.....do	......	......	......	37.5	......	29.5	14.5	11.5	24.5	......	13.5	22	39.5	......	......	13	......	......	......
55017	♀	.... do	58	55	51	37	37.5	28	15	10	23.5	17.5	14	20.5	38.5	40	15	12.5	67.2	68.1	42.7
55018	♀	.....do	......	......	......	36	37	28	15	11.5	23.5	17	13.5	......	38	41	15.5	......	......	......	......
		Heterogeomys torridus.																			
63629	♀ ad	Chichicaxtle, Vera Cruz, Mexico (*type*).	60.5	57	52.5	41	39	28	15.5	11	23	18	13.5	21	41	46.5	17.5	15	71.9	68.4	40
63645	♂ ad	Motzorongo, Vera Cruz	60.5	57	52	41.5	40.5	30	14	11	23.5	18	13.5	21.5	40	45	16.5	15	72.8	71	41
63632	♂ ad	.....do	63.5	60	55.5	43.5	41	30	15.5	10.5	25	19.5	14.5	23	42	46	18	15	72.5	68.3	40.1
63635	♀	.....do	57	54	50	38.5	38	29	13.5	11	23.5	18	13	21	38	42	16	12.5	71.2	70.3	33.3
63651	♀	.....do	57	54	50	37	36	28	13.5	10.5	23	18	13	20.5	38.5	42	15.5	13.5	68.5	66.6	33.3

* Type of *Geomys nelsoni* Merriam. † British Museum. ‡ Measured by Oldfield Thomas. ¶ Berlin Museum. § Measured by Dr. Paul Matschie.

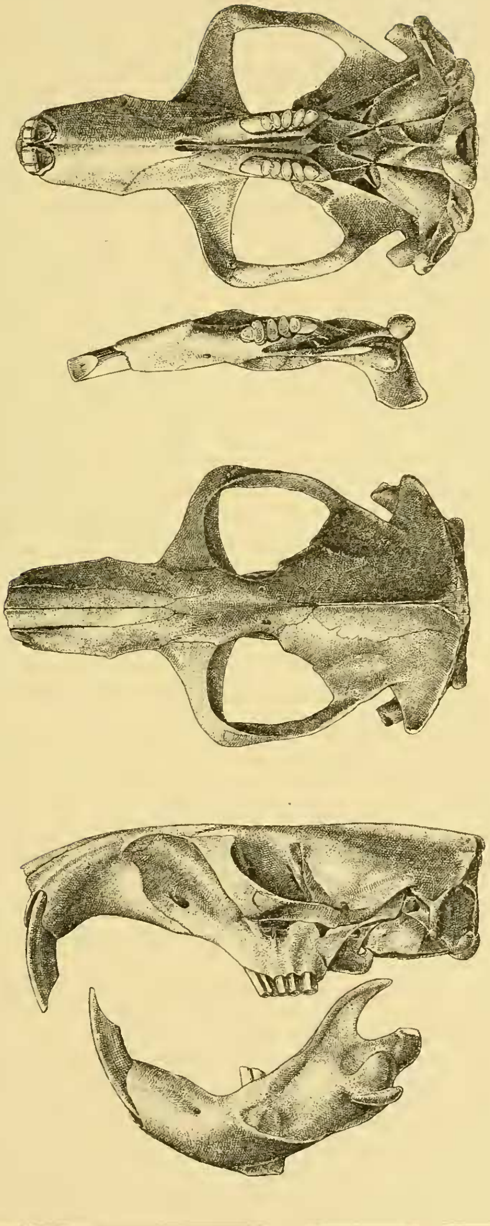
INDEX.

[Names of genera and species are in heavy type.]

PLATE 1.

(All natural size.)

Geomys bursarius (Shaw). Knoxville, Iowa.
(No. 2772 ♂ ad. Merriam collection.)



Benj Mortimer del. Nat. size B Meisel, phot.

GEOMYS BURSARIUS (Shaw)

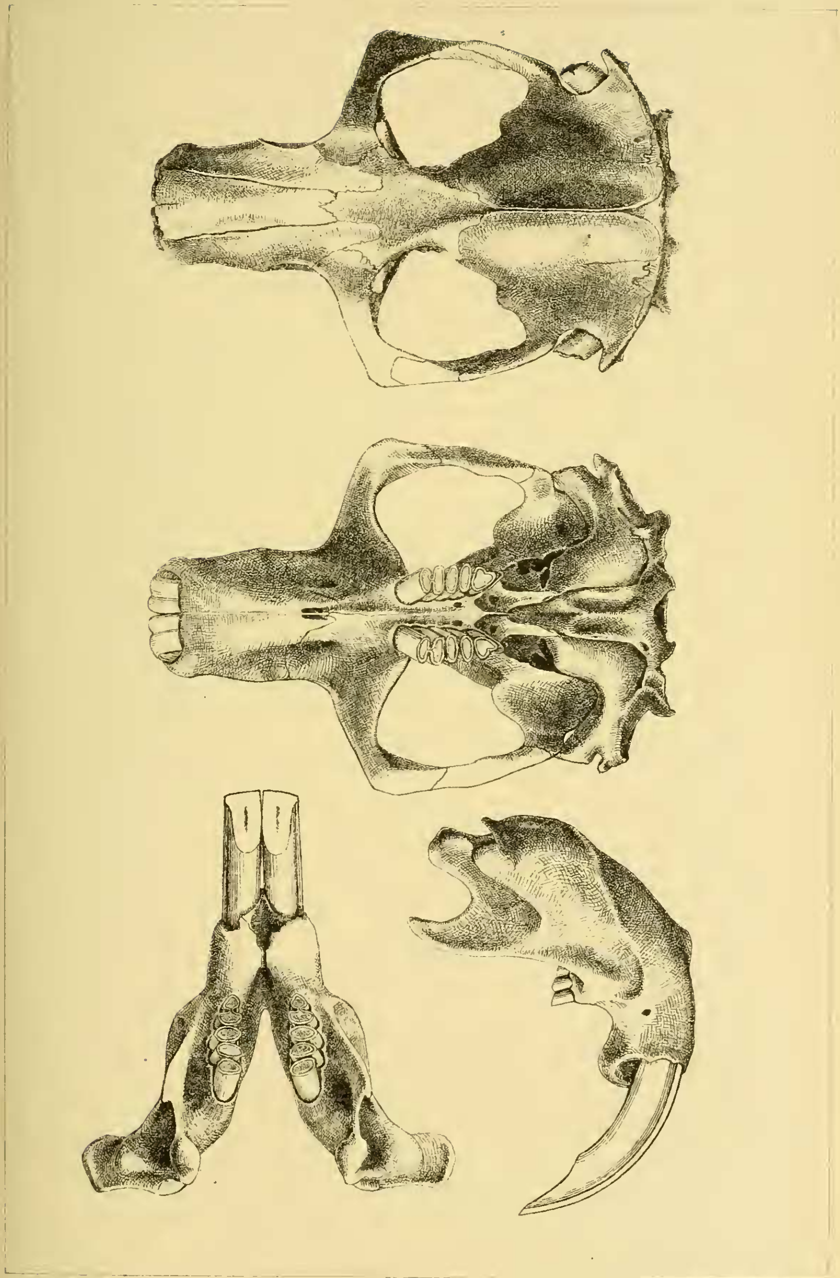
Knoxville, Iowa.

No. 2772. ♂ ad.

PLATE 2.

(All natural size.)

Cratogeomys merriami (Thomas). Lerma, Mexico.
(No. 50110 ♂ ad. U. S. Nat. Mus.)



F. Muller, del. Nat size B. Meisel photo.

GEOMYS MERRIAMI Thomas

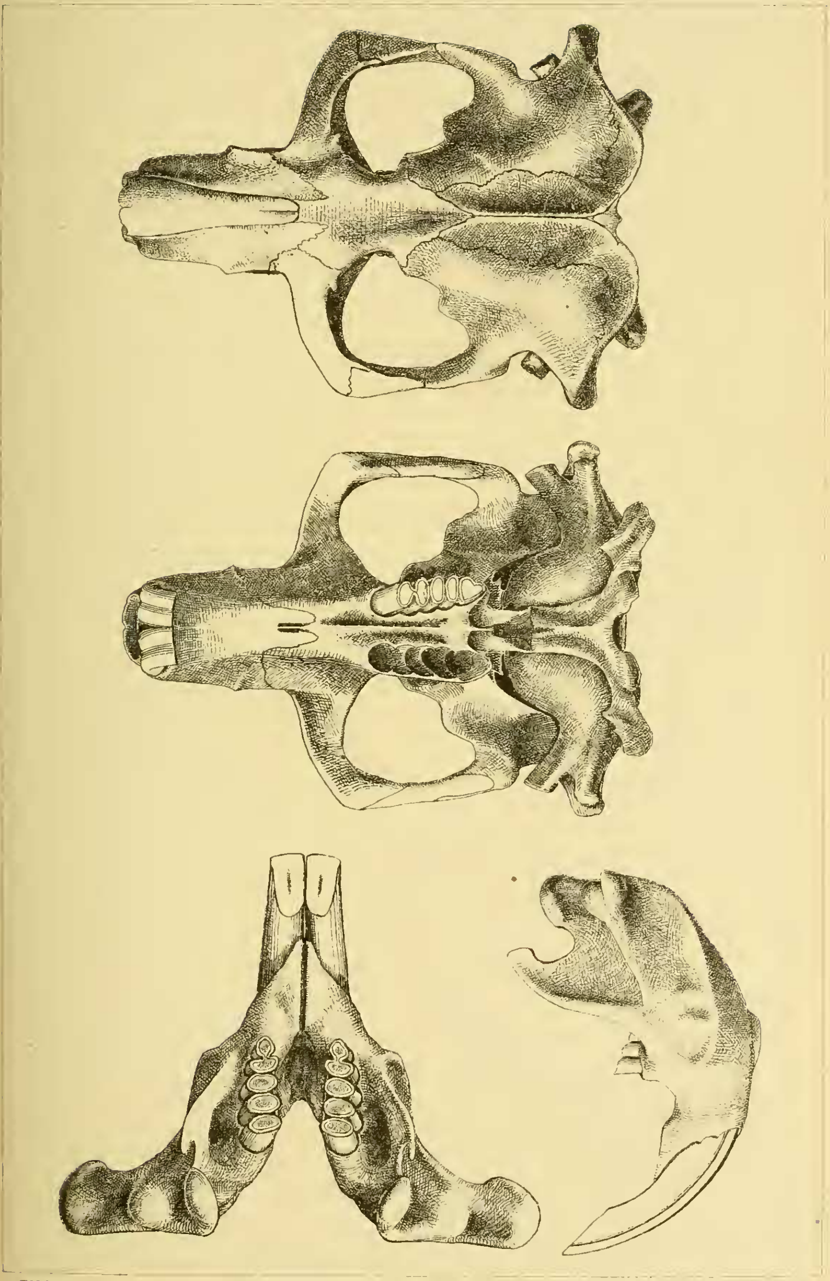
Lerma, Mexico.

No. 50110, ♂ ad

PLATE 3.

(All natural size.)

Platygeomys gymnurus Merriam. Zapotlan, Jalisco, Mexico.
(No. 45611 ♂ ad. U. S. Nat. Mus.)



F. Muller, del. Nat size B Meisel [illegible]

GEOMYS GYMNURUS Merriam

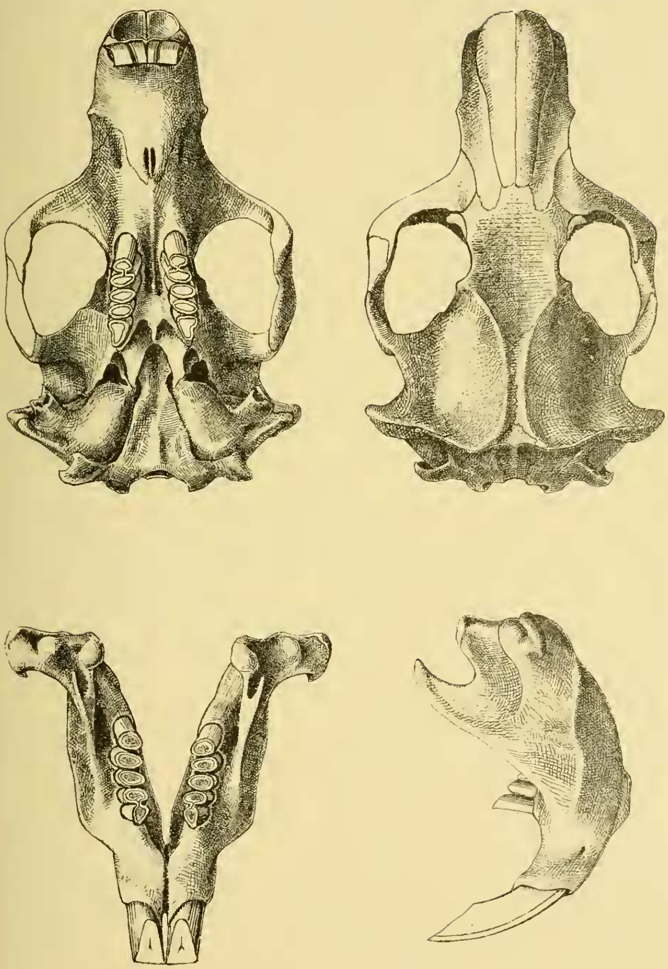
Zapotlan, Mexico.

No. 45611. ♂ ad.

PLATE 4.

(All natural size.)

Heterogeomys hispidus (LeConte). Jico, Vera Cruz, Mexico.
(No. 55343 U. S. Nat. Mus.)



F. Muller, del. Nat. size B. Meis... p.

GEOMYS HISPIDUS. Le Conte

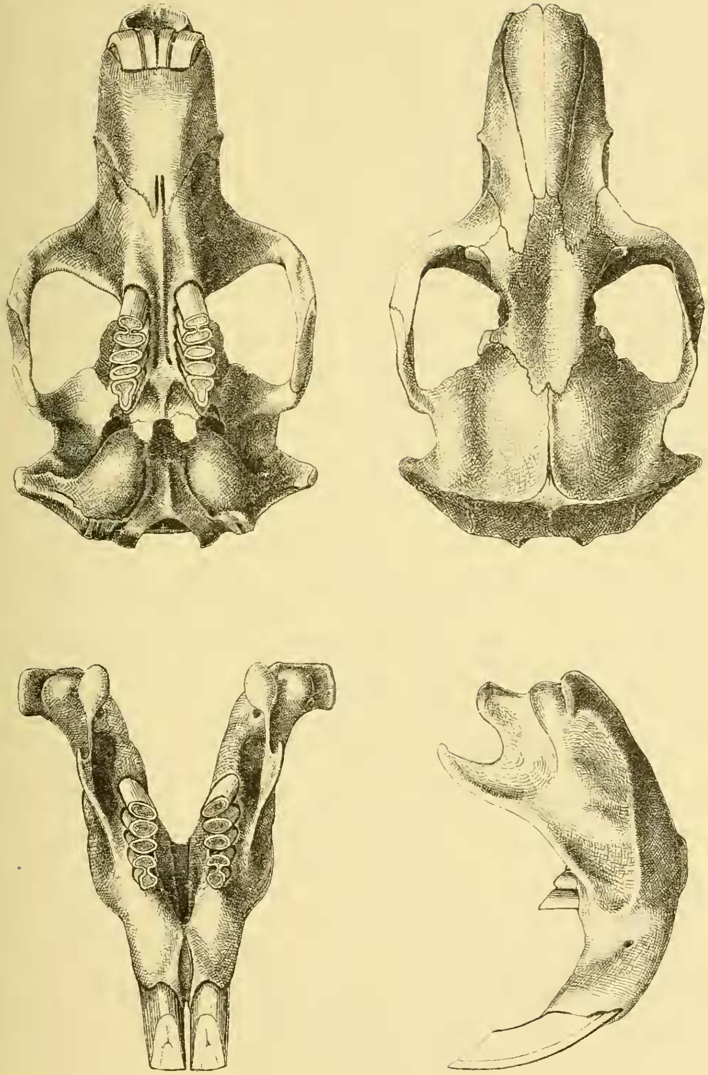
Jico, Vera Cruz, Mexico.

No. 55343. ♂ ad.

PLATE 5.

(All natural size.)

Macrogeomys dolichocephalus sp. nov. San Jose, Costa Rica.
(No. 36295 ♂ ad., U. S. Nat. Mus.)



F. Muller, del.

B. Meisel

GEOMYS DOLICHOCEPHALUS sp. nov.

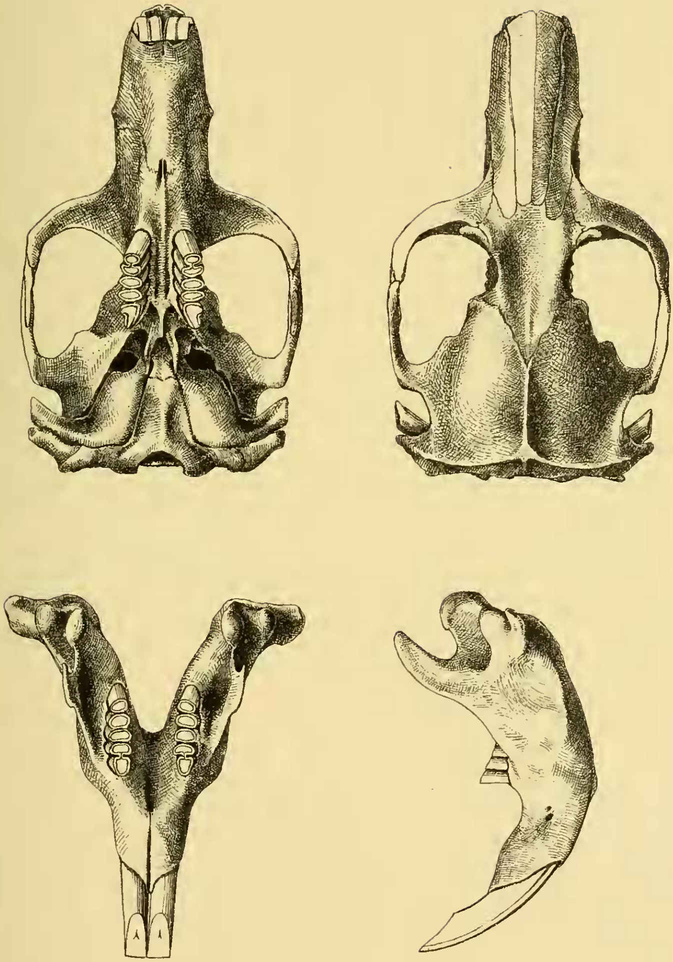
San José, Costa Rica.

No 36295.

PLATE 6.

(All natural size.)

Zygogeomys trichopus sp. nov. Nahuatzin, Michoacan, Mexico. (No. 50107 ♂ ad., U. S. Nat. Mus.)



F. Muller, del. Nat. size B. Meisel, photo.

GEOMYS TRICHOPUS Merriam

Nahuazin, Michoacan, Mexico.

No. 50107. ♂ ad.

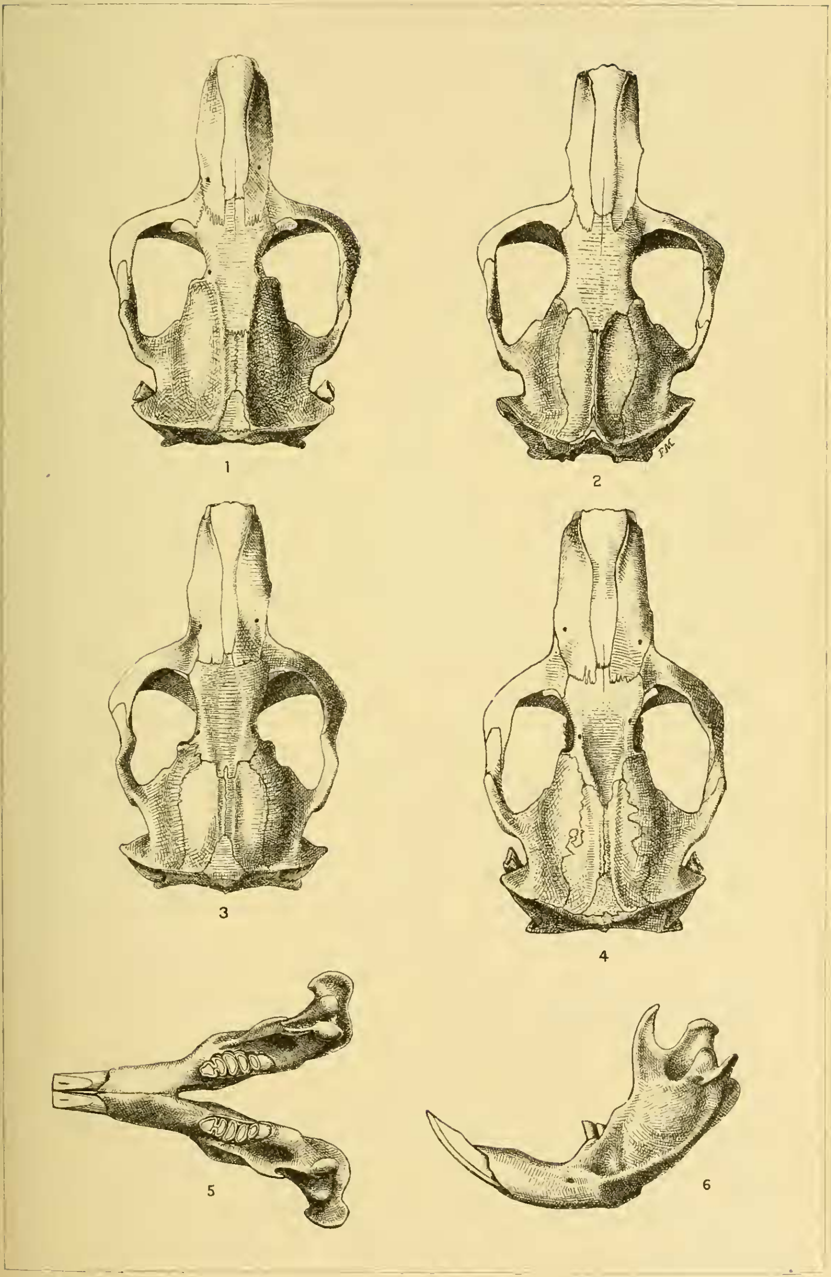
PLATE 7.

(All natural size.)

1. *Geomys tuza* (Ord) ♂ ad. Augusta, Ga. (Type locality).
   (No. 58639 U. S. Nat. Mus.)

2, 5, 6. *G. tuza mobilensis* ♂ ad. Mobile Bay, Alabama. (Type locality).
   (No. 46024 U. S. Nat. Mus.)

3 and 4. *G. tuza floridanus* ♂ ad. San Mateo, Fla.
   (No. 6512 ♂ ad. and 6514 ♂ old, Merriam collection.)



F. Muller, del. Nat. size B. Meisel, photo. lith.

1. GEOMYS TUZA ♂ 2, 5 & 6. G. MOBILENSIS ♂ 3 & 4. G. TUZA FLORIDANUS ♂

PLATE 8.

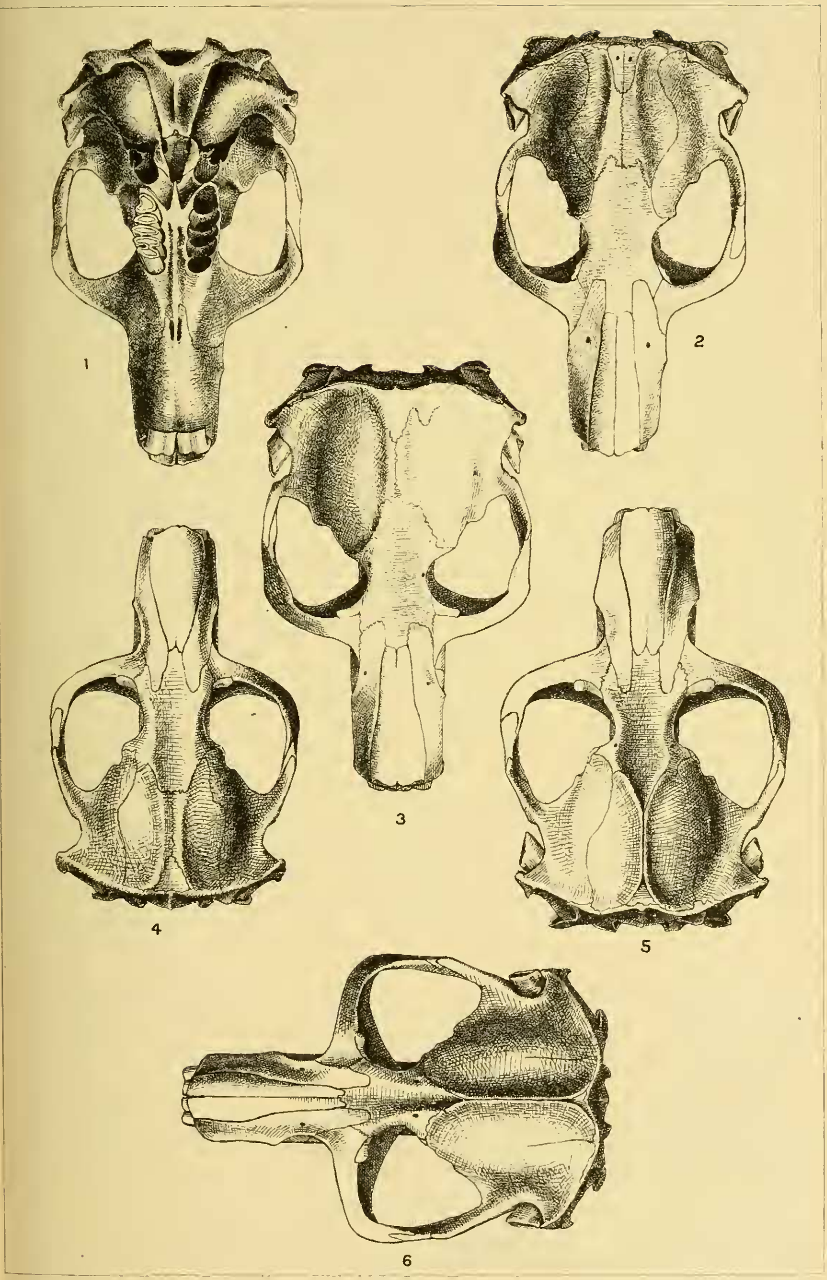
(All natural size.)

1 & 2. *Cratogeomys oreocetes* sp. nov. ♀ ad. Mount Popocatapetl, Mexico. *Type.* (No. 57963 U. S. Nat. Mus.)

3. *C. peregrinus* sp. nov. ♀ ad. Mount Iztaccihuatl, Mexico. *Type.* (No. 57964 U. S. Nat. Mus.)

4 & 5. *C. estor* sp. nov. Las Vigas, Vera Cruz, Mexico. (4 = No. 54306 ♀ ad. and 5 = 54308 ♂ ad. U. S. Nat. Mus.)

6. *C. perotensis* sp. nov. ♀ ad. Cofre de Perote, Vera Cruz, Mexico. (No. 54299 U. S. Nat. Mus.)



E Muller, del. Nat. size B Meisel, photo lith.

1 & 2 ♀ ad. GEOMYS OREOCETES
4 ♀ & 5 ♂ G. ESTOR

3 ♀ ad. G. PEREGRINUS
6 ♀ ad. G. PEROTENSIS

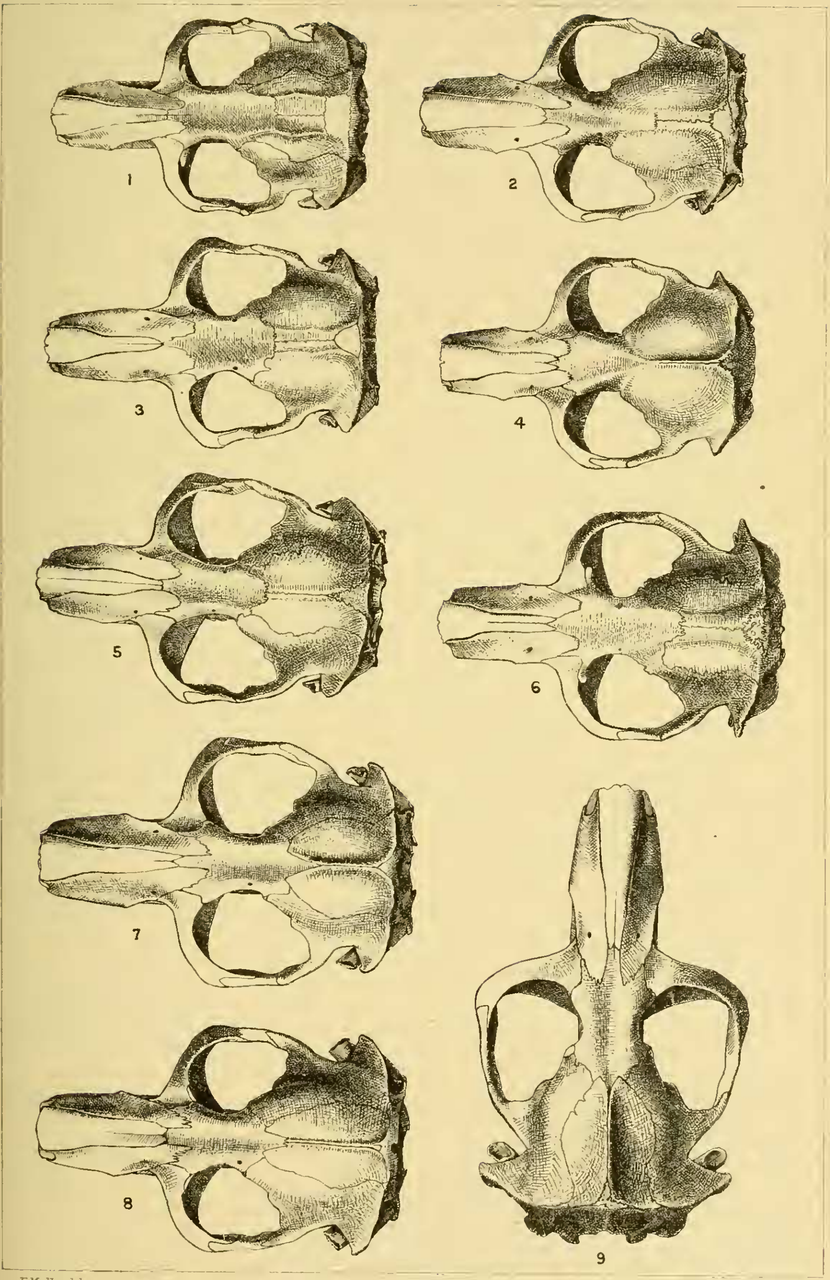
PLATE 9.

(All natural size.)

1. *Geomys arenarius* ♂ ad. El Paso, Texas.
   (No. 58339 U. S. Nat. Mus.)
2. *G. texensis* ♂ Mason, Texas.
   (No. 4161 Merriam collection.)
3. *G. attwateri* ♂ ad. Rockport, Aransas County, Texas.
   (No. 51382 U. S. Nat. Mus.)
4. *G. sagittalis* ♂ ad. Galveston Bay, Texas.
   (No. 44957 U. S. Nat. Mus.)

5 & 7. *G. lutescens* ♂ ad. Cherry County, Nebraska.
   (5 = 25640 ♂ yg. ad.; 7 = 25471 ♂ old, U. S. Nat. Mus.)

6. *G. breviceps* ♂ ad. Mer Rouge, Louisiana.
   (No. 46673 U. S. Nat. Mus.)
8. *G. bursarius* ♀ ad. Knoxville, Iowa.
   (No. 2024 Merriam collection.)
9. *G. bursarius* ♂ ad. Knoxville, Iowa.
   (No. 2625 Merriam collection.)



F. Muller, del. Nat. size B. Meisel, photo lith.

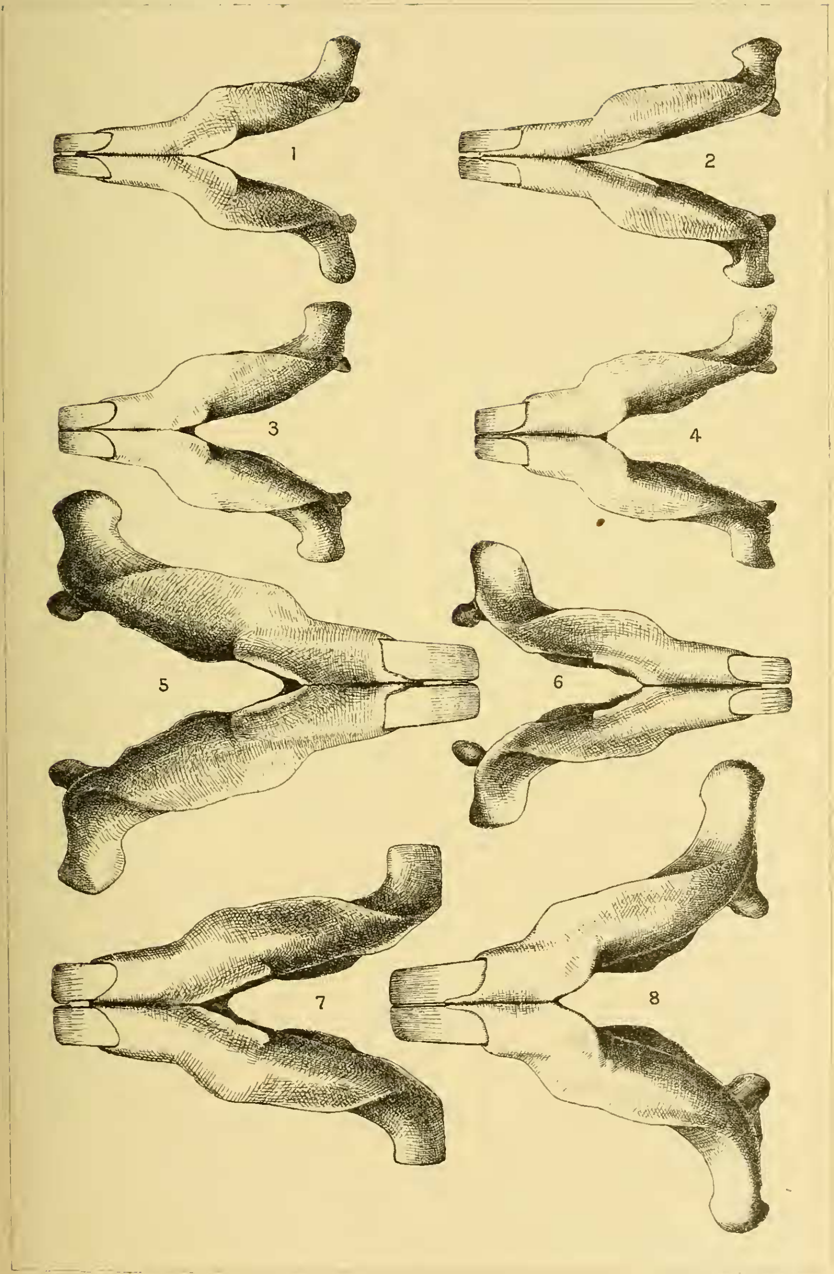
1. GEOMYS ARENARIUS ♂ ad. 2. G. TEXENSIS ♂ ad. 3. G. ATTWATERI ♂ ad. 4. G. SAGITTALIS ♂ ad.
5 & 7. G. LUTESCENS ♂ ad. 6. G. BREVICEPS ♂ ad. 8 ♀ ad. 9 ♂ ad. G. BURSARIUS

PLATE 10.

Under side of mandible.

(All natural size.)

1. *Geomys tuza floridanus* (Bachman). San Mateo, Florida. (No. 6511 ♂ Merriam collection.)
2. *G. tuza mobilensis* sp. nov. Mobile Bay, Alabama. (No. 46023 ♂ U. S. Nat. Mus.)
3. *Cratogeomys oreocetes* sp. nov. Mount Popocatapetl, Mexico. (No. 57963 ♀ U. S. Nat. Mus.)
4. *C. peregrinus* sp. nov. Mount Iztaccihuatl, Mexico. (No. 57964 ♀ U. S. Nat. Mus.)
5. *C. merriami* (Thomas). Amecameca, Mexico. (No. 57970 ♂ U. S. Nat. Mus.)
6. *Geomys bursarius* (Shaw). Knoxville, Iowa. (No. 2772 ♂ Merriam collection.)
7. *Macrogeomys dolichocephalus* sp. nov. San Jose, Costa Rica. (No. 36295 ♂ U. S. Nat. Mus.)
8. *Platygeomys gymnurus* Merriam. Zapotlan, Jalisco, Mexico. (No. 45611 ♂ U. S. Nat. Mus.)



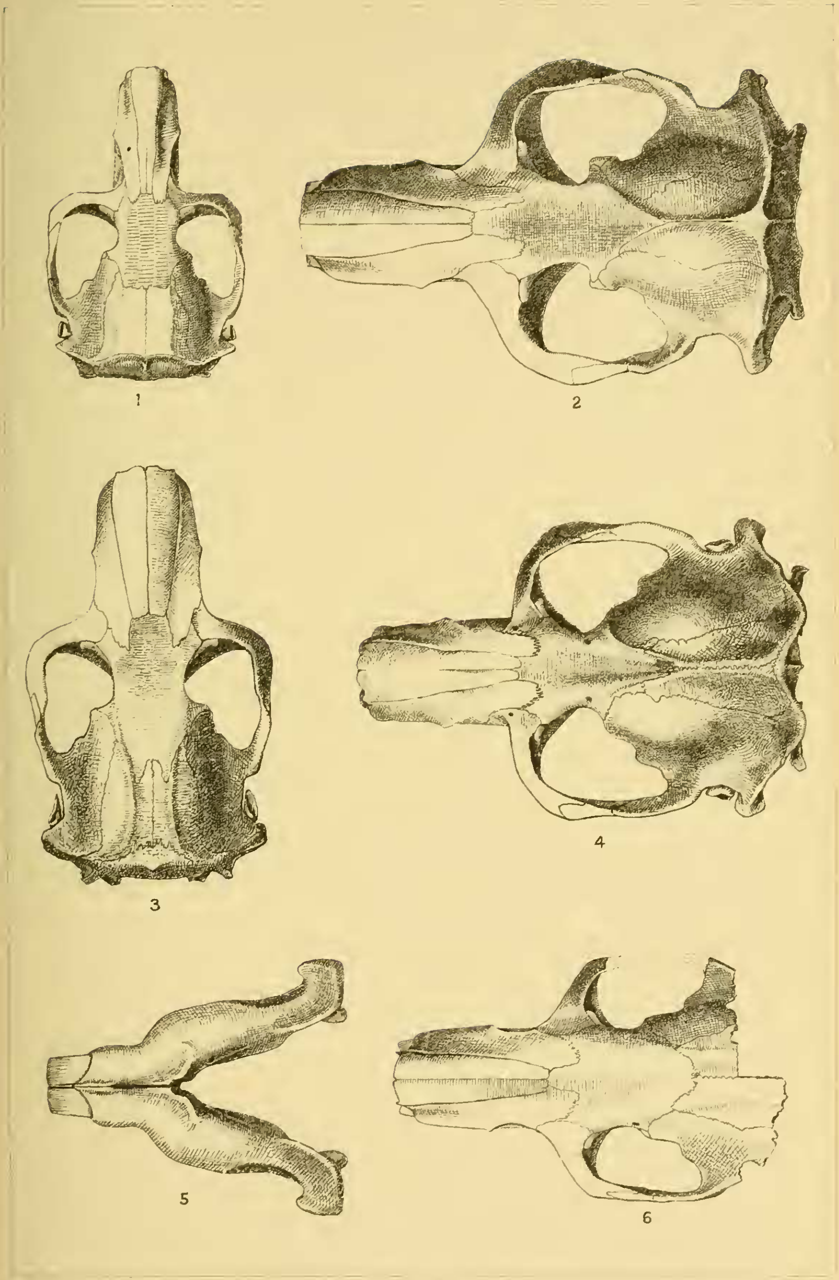
F. Muller, del. Nat. size

1 GEOMYS TUZA FLORIDANUS ♂ 2 G. MOBILENSIS ♂ 3. G. OREOCETES ♀ 4. G. PEREGRINUS ♀ 5. G. MERRIAMI ♂ 6. G. BURSARIUS ♂ 7. G. DOLICHOCEPHALUS ♂ 8. G. GYMNURUS ♂

PLATE 11.

(All natural size.)

1. *Pappogeomys bulleri* (Thomas). Sierra Nevada de Colima, Jalisco, Mexico. (No. 45622 ♂ U. S. Nat. Mus.)
2. *Macrogeomys heterodus* (Peters). Costa Rica, Mexico. (No. ——— ♂ U. S. Nat. Mus.)
3. *Heterogeomys costaricensis* sp. nov. Pacuare, Costa Rica. (No. 22551, sex ?, U. S. Nat. Mus.) *Type.*
4. *Platygeomys fumosus* Merriam. Colima City, Mexico. (No. 45211 ♂ U. S. Nat. Mus.)
5. *Orthogeomys latifrons* sp. nov. Guatemala. (No. ———, sex ?, U. S. Nat. Mus.) *Type.*
6. *O. latifrons* (under side of mandible of same skull as 5.)



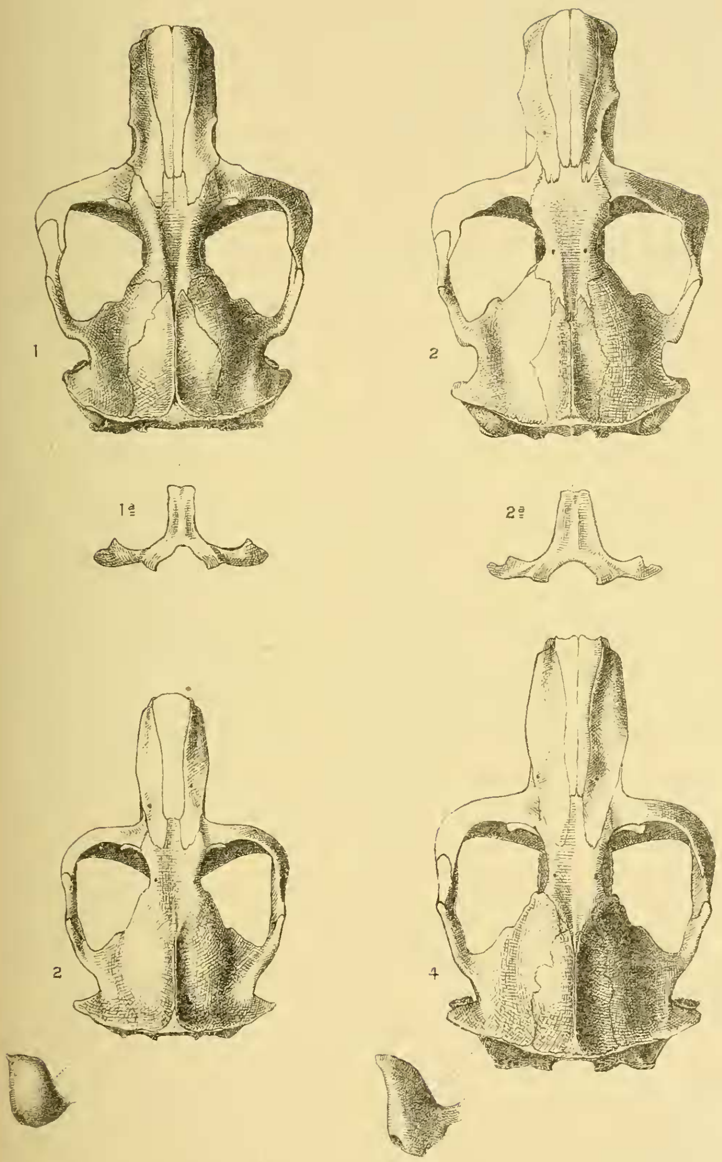
F Muller, del. Nat. size B Metsel

1. GEOMYS BULLERI. 2. G. HETERODUS ♂ 3. G. COSTARICENSIS
4. G. FUMOSUS ♂ 5 & 6. G. LATIFRONS

PLATE 12.

(All natural size.)

1. *Cratogeomys castanops* (Baird). Las Animas, Colorado. (Type locality.)
   (No. 47368 ♂ U. S. Nat. Mus.)
   1a. Basioccipital of same specimen.
2. *Cratogeomys fulvescens* sp. nov. Chalchicomula, Mexico. (Type locality.)
   (No. 53498 ♂ U. S. Nat. Mus.)
   2a. Basioccipital of same specimen.
3. *Geomys personatus fallax* subsp. nov. Corpus Christi, Texas. *Type.*
   (No. 43845 ♂ ad. U. S. Nat. Mus.)
   3a. Left audital bulla of same skull.
4. *Geomys personatus* True. Padre Island, Texas. (Type locality.)
   (No. 43294 ♂ U. S. Nat. Mus.)
   4a. Left audital bulla of same skull.



F. Muller del. B. Meisel

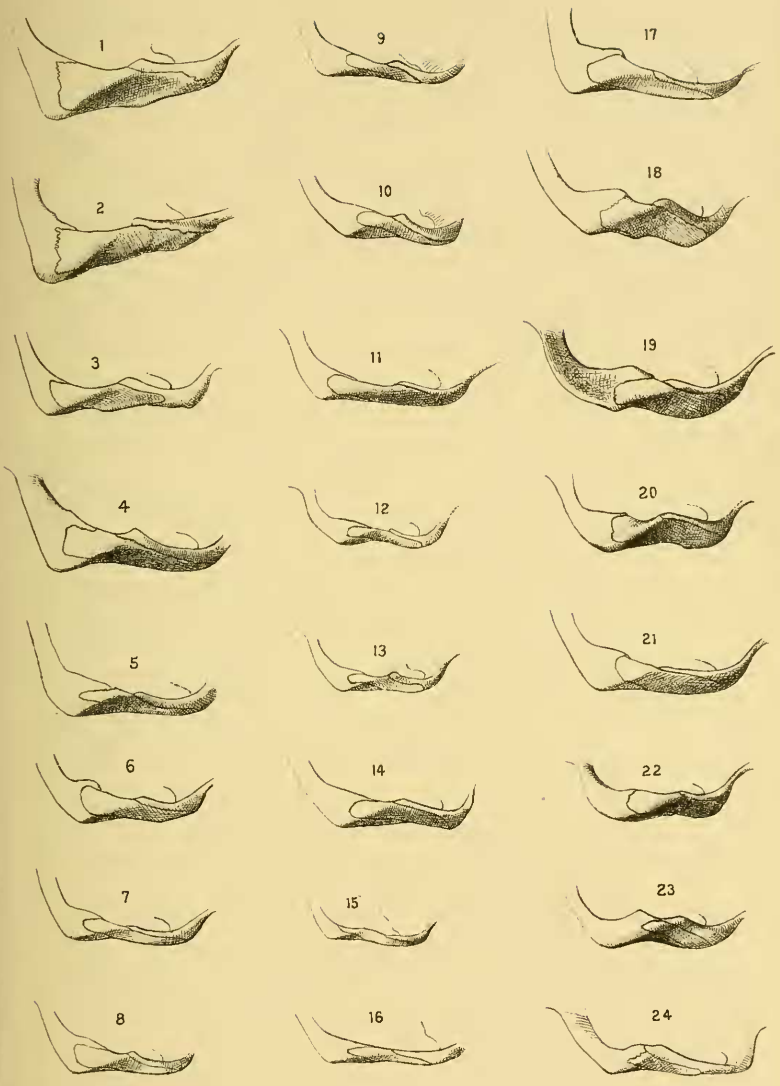
1. GEOMYS CASTANOPS 2. G. FULVESCENS
3. G. PERSONATUS FALLAX 4. G. PERSONATUS

PLATE 13.

Left zygoma, showing variations in jugal bone.

(All natural size.)

1. *Platygeomys tylorhinus* sp. nov. Patzcuaro, Mexico.
   (No. 47183 ♂ U. S. Nat. Mus.)
2. *P. gymnurus* Merriam. Zapotlan, Mexico.
   (No. 45611 ♂ U. S. Nat. Mus.)
3. *P. planiceps* sp. nov. Tula, Hidalgo, Mexico.
   (No. 55906 ♂ U. S. Nat. Mus.)
4. *Cratogeomys merriami* (Thomas). Lerma, Mexico.
   (No. 50110 ♂ U. S. Nat. Mus.)
5. *C. perotensis* sp. nov. Cofre de Perote, Mexico.
   (No. 54295 ♀ U. S. Nat. Mus.)
6. *C. estor* sp. nov. Las Vigas. Mexico.
   (No. 54308 ♂ U. S. Nat. Mus.)
7. *C. estor* sp. nov. Las Vigas, Mexico.
   (No. 54306 ♀ U. S. Nat. Mus.)
8. *C. oreocetes* sp. nov. Mount Popocatapetl, Mexico.
   (No. 57963 ♀ U. S. Nat. Mus.)
9. *Geomys tuza* (Ord). Augusta, Georgia.
   (No. 63842 ♂ U. S. Nat. Mus.)
10. *G. tuza floridanus* (Aud. and Bach.). San Mateo, Florida.
   (No. 6514 ♂ Merriam collection.)
11. *G. bursarius* (Shaw). Knoxville, Iowa.
   (No. 2624 ♂ Merriam collection.)
12. *G. texensis* sp. nov. Mason, Texas.
   (No. 4161 ♂ Merriam collection.)
13. *G. arenarius* sp. nov. El Paso, Texas.
   (No. 25015 ♂ U. S. Nat. Mus.)
14. *G. personatus* True. Padre Island., Texas.
   (No. 43294 ♂ U. S. Nat. Mus.)
15. *Pappogeomys bulleri* (Thomas). Sierra Nevada de Colima, Mexico.
   (No. 45618 ♀ U. S. Nat. Mus.)
16. *Orthogeomys latifrons* sp. nov. Guatemala. *Type.*
   (No. ——— U. S. Nat. Mus)
17. *Cratogeomys castanops* (Baird). Las Animas, Colorado.
   (No. 47368 ♂ U. S. Nat. Mus.)
18. *Macrogeomys heterodus* (Peters). Costa Rica.
   (No. ——— U. S. Nat. Mus.)
19. *Macrogeomys dolichocephalus* sp. nov. San Jose, Costa Rica.
   (No. 36295 ♂ U. S. Nat. Mus.)
20. *Heterogeomys hispidus* (LeConte). Jico, Vera Cruz, Mexico.
   (No. 55343 ♂ U. S. Nat. Mus.)
21. *Heterogeomys torridus* sp. nov. Guatemala.
   (No. ——— ♂ U. S. Nat. Mus.)
22. *Macrogeomys cherriei* (Allen). Santa Clara, Costa Rica.
   (No. 664 im. Costa Rica Nat. Museum.)
23. *Macrogeomys costaricensis* sp. nov. Pacuare, Costa Rica.
   (No. 22551 im. U. S. Nat. Mus.)
24. *Zygogeomys trichopus* sp. nov. Nahuatzin, Michoacan, Mexico.
   (No. 50107 ♂ U. S. Nat. Mus.)



F Muller, del. Nat. size B Meisel, [illegible]

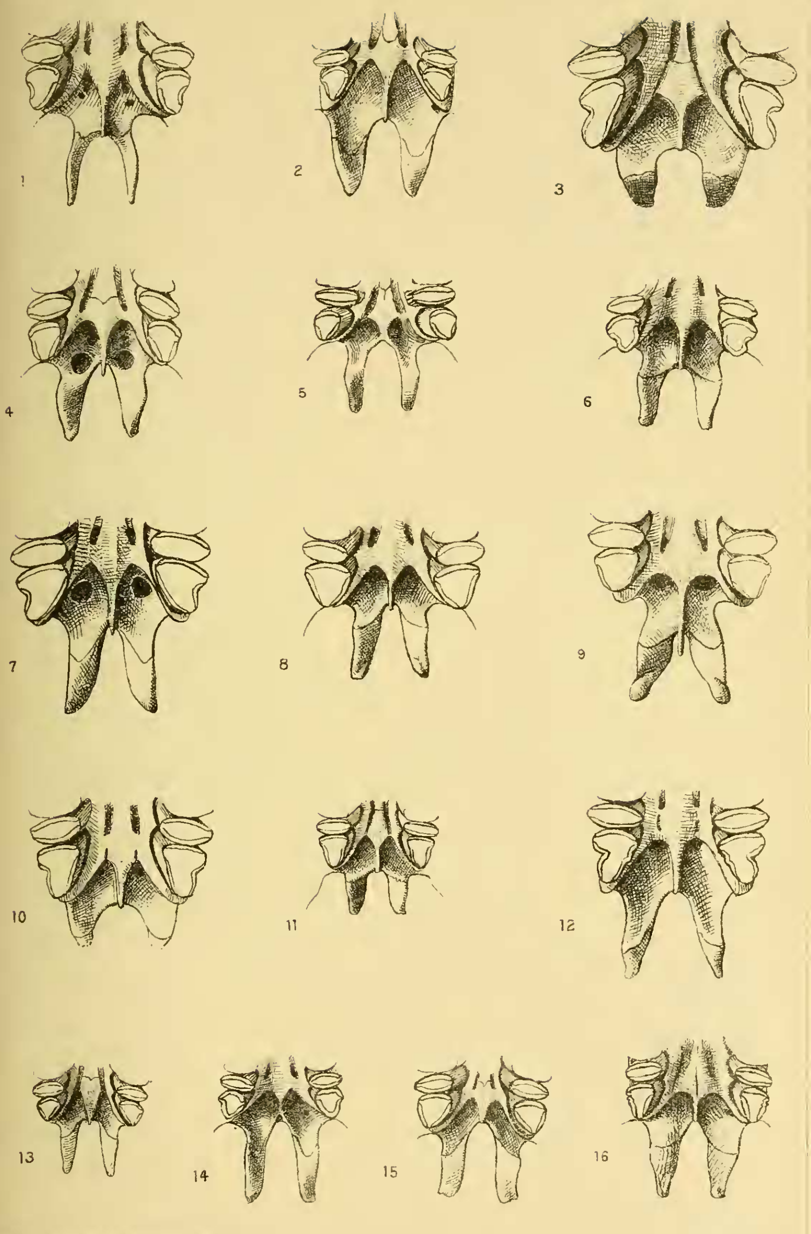
1. GEOMYS TYLORHINUS ♂
2. GYMNURUS ♂
3. PLANICEPS ♂
4. MERRIAMI ♂
5. PEROTENSIS ♀
6. ESTOR ♂
7. ESTOR ♀
8. OREOCETES ♀
9. TUZA ♂
10. TUZA FLORIDANUS ♂
11. BURSARIUS ♂
12. TEXENSIS ♂
13. ARENARIUS ♂
14. PERSONATUS ♂
15. BULLERI ♀
16. LATIFRONS
17. CASTANOPS ♂
18. HETERODUS ♂
19. DOLICHOCEPHALUS ♂
20. HISPIDUS ♂
21. HISPIDUS. (form)
22. CHERRIEI
23. COSTARICENSIS
24. TRICHOPUS ♂

PLATE 14.

Posterior molars and palatopterygoids.

(All double natural size.)

1. *Zygogeomys trichopus* sp. nov. Nahuatzin, Michoacan, Mexico. (No. 50107 ♂ U. S. Nat. Mus.)
2. *Geomys bursarius* (Shaw). Knoxville, Iowa. (No. 2624 ♂ Merriam collection.)
3. *Macrogeomys heterodus* (Peters). Costa Rica. (No. —— U. S. Nat. Mus.)
4. *Geomys personatus* True. Padre Island, Texas. (No. 43294 ♂ U. S. Nat. Mus.)
5. *Geomys personatus fallax* subsp. nov. Corpus Christi, Texas. (No. 43292 ♀ U. S. Nat. Mus.)
6. *Cratogeomys castanops* (Baird). Las Animas, Colorado. (No. 47368 ♂ U. S. Nat. Mus.)
7. *Cratogeomys merriami* (Thomas). Lerma, Mexico. (No. 50110 ♂ U. S. Nat. Mus.)
8. *Platygeomys fumosus* Merriam. Colima, Mexico. (No. 45213 ♂ U. S. Nat. Mus.)
9. *Platygeomys planiceps* sp. nov. Volcan Toluca, Mexico. (No. 55906 ♂ U. S. Nat. Mus.)
10. *Macrogeomys costaricensis* sp. nov. Costa Rica. *Type.* (No. 22551 U. S. Nat. Mus.)
11. *Pappogeomys bulleri* (Thomas). Sierra Nevada de Colima, Jalisco, Mexico. (No. 45618 ♀ U. S. Nat. Mus.)
12. *Heterogeomys hispidus* (LeConte). Jico, Vera Cruz, Mexico. (No. 55017 ♀ U. S. Nat. Mus.)
13. *Geomys texensis* sp. nov. Mason, Texas. (No. 4168 ♀ Merriam Collection.)
14. *Geomys lutescens* Merriam. Woodward, Oklahoma. (No. 48566 ♂ U. S. Nat. Mus.)
15. *Geomys tuza mobilensis* sp. nov. Mobile Bay, Alabama. (No. 46025 ♂ U. S. Nat. Mus.)
16. *Geomys tuza floridanus* (Aud. and Bach.). San Mateo, Florida. (No. 6511 ♂ Merriam Collection.)



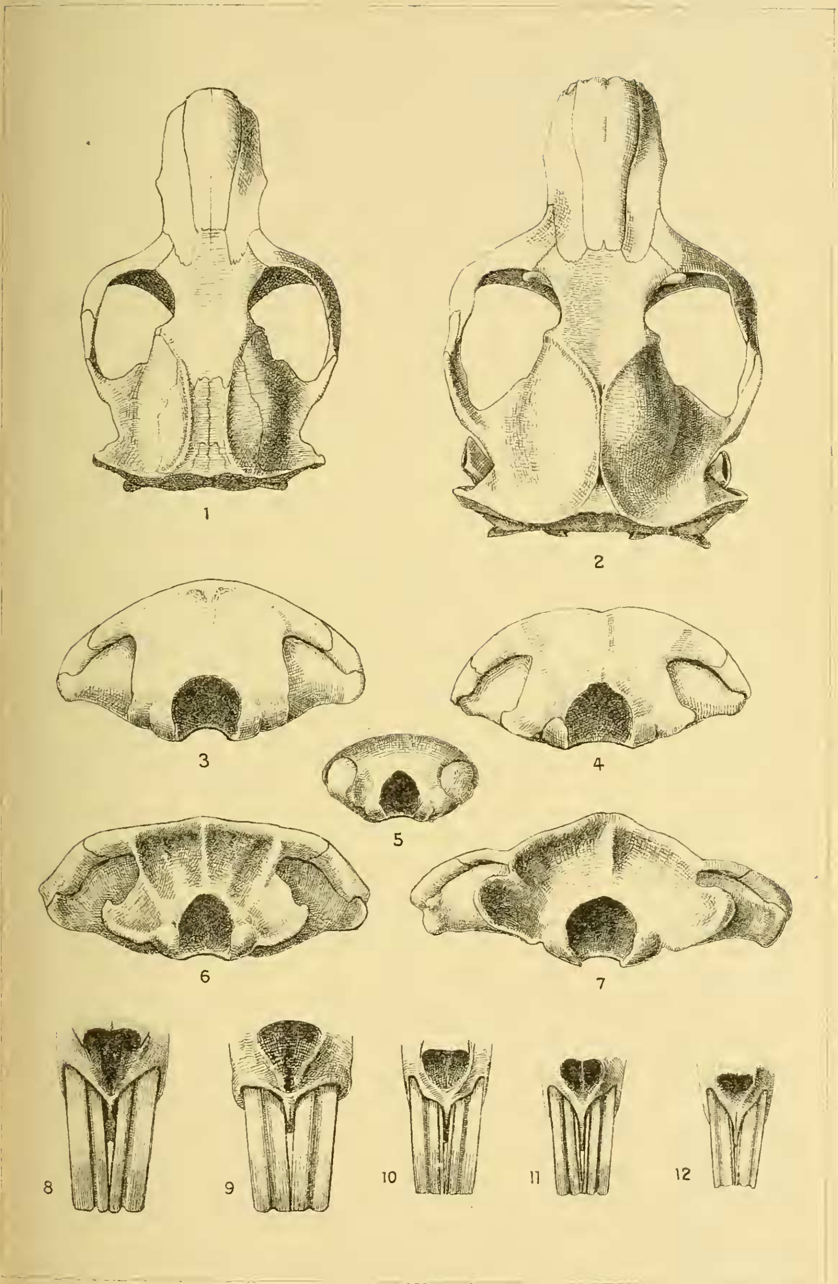
F. Muller, del. Double nat. size B. Meisel [illegible]

1. GEOMYS TRICHOPUS nob.
2. BURSARIUS (Shaw)
3. HETERODUS Peters
4. PERSONATUS True
5. PERSONATUS FALLAX nob.
6. CASTANOPS Baird
7. MERRIAMI Thomas
8. FUMOSUS Merriam
9. G. PLANICEPS nob.
10. COSTARICENSIS nob.
11. BULLERI Thomas
12. HISPIDUS Le Conte
13. TEXENSIS nob.
14. LUTESCENS Merriam
15. MOBILENSIS nob.
16. TUZA FLORIDANUS (Bachman)

PLATE 15.

(All natural size.)

1. *Macrogeomys cherriei* (Allen). Santa Clara, Costa Rica. (No. 664 im Museo Nacional de Costa Rica). *Type.*
2. *Heterogeomys torridus* sp. nov. Chichicaxtle, Vera Cruz, Mexico. (No. 63629 ♀ ad. U. S. Nat. Mus.). *Type.*
3. Occiput of *Macrogeomys dolichocephalus* sp. nov. San Jose, Costa Rica. (No. 36295 ♂ ad. U. S. Nat. Mus.). *Type.*
4. Occiput of *Heterogeomys hispidus* (LeConte). Jico, Vera Cruz, Mexico. (No. 55343 ♂ ad. U. S. Nat. Mus.)
5. Occiput of *Pappogeomys bulleri* (Thomas). Sierra Nevada de Colima, Jalisco, Mexico. (No. 45618 ♀ yg. ad. U. S. Nat. Mus.)
6. Occiput of *Cratogeomys merriami* (Thomas). Lerma, Mexico. (No. 50110 ♂ ad. U. S. Nat. Mus.)
7. Occiput of *Platygeomys gymnurus* Merriam. Zapotlan, Jalisco, Mexico. (No. 45611 ♂ ad. U. Nat. Mus.)
8. Upper incisors of *Macrogeomys dolichocephalus.*
9. Upper incisors of *Cratogeomys merriami.*
10. Upper incisors of *Zygogeomys trichopus.*
11. Upper incisors of *Geomys bursarius.*
12. Upper incisors of *Geomys tuza.*



F. Muller, del. Nat. size B Meisel, photo-lith.

I. GEOMYS CHERRIEI 2. G. TORRIDUS 3 & 8. G. DOLICHOCEPHALUS
4. G. HISPIDUS 5. G. BULLERI 6 & 9. G. MERRIAMI 7. G. GYMNURUS
10. G. TRICHOPUS 11. G. BURSARIUS 12. G. TUZA.

PLATE 16.

1 and 2. *Heterogeomys torridus* juv. Motzorongo, Mexico (No. 63643 U. S. National Museum).

Molariform teeth, showing deciduous premolars in situ; also unworn m 3, and immature pattern of crowns in m 1 and 2.

1. Left upper series.
2. Left lower series.

1*x*. Permanent upper premolar, uncovered to show unworn enamel crown.

a, Permanent premolar not yet in place; *b*, deciduous premolar; *c*, third upper molar; *d*, third lower molar.

3, 4, and 9. *Geomys bursarius* juv. Elk River, Minn. (No. 4909 Merriam coll.)

Molariform teeth, showing deciduous premolars in situ; also unworn m 3, and immature pattern of crowns in m 1 and 2.

3. Left upper series.
4. Left lower series.

4*x*. Transverse section of m_2 about three-fourths down, showing that the tooth is a single prism below, and that the enamel is confined to its posterior border.

9. Left lower series from outer side, showing relations of permanent and deciduous premolar, bilophiodont crown of m_3, and forms of m_1 and m_2 (which show the manner in which the change occurs from the double prism above to the single prism below).

a, Permanent premolar not yet in place; *b*, deciduous premolar; *c*, third upper molar; *d*, third lower molar.

5, 6, and 7. *Heterogeomys torridus* juv. (same specimen as in fig. 1).

Right upper premolar, showing unworn enamel cap and relations of enamel and cement. The cement bands are shaded.

5. Outer side of tooth.
6. Inner side.
7. Posterior face.

a, Outer cement band of anterior prism; *b*, postero-external cement band of posterior prism; *c*, inner cement band of posterior prism; *d*, inner cement band of anterior prism; *e*, lower end of enamel, showing position of enamel organ.

8. *Macrogeomys heterodus* ad.

Right upper premolar, showing relation of cement bands (unshaded) to enamel (shaded) in mature tooth after the enamel cap [shown in figs. 5, 6, and 7] has worn off.

10 and 11. *Zygogeomys trichopus* juv. Nahuatzin, Mexico (No. 50104 U. S. Nat. Mus.).

Crowns of molariform series showing permanent enamel pattern and 'osteodentine' islands.

10. Left upper series.
11. Left lower series.

12 and 13. *Heterogeomys hispidus* ad. Motzorongo, Mexico.

Right upper premolar, after the enamel cap of the young tooth has worn off, showing permanent enamel pattern.

12. Outer side of the tooth (should be compared with 5, which shows same side of same tooth before the wearing down of the enamel cap begins).
13. Crown of same tooth.

a. Outer cement band of anterior prism.
b. Postero-external cement band of posterior prism.
Shaded bands show the enamel.

14–17. *Cratogeomys castanops* juv. Las Animas, Colorado.

14 and 15. A very young individual, but older than Nos. 1 and 4. The deciduous premolars have been shed, but the enamel caps of the permanent premolars (*a*) and the last true molars (m^3c and m_3d) have not yet worn down far enough to show the enamel pattern of the adult tooth (which may be seen in figs. 16 and 17). The crown of the last lower molar (*d*) is still a double prism.

16 and 17. Another immature individual of the same species, but enough older than 14 and 15 to show the permanent form and enamel pattern of the adult teeth.

18 and 19. *Geomys bursarius* im. Elk River, Minnesota.

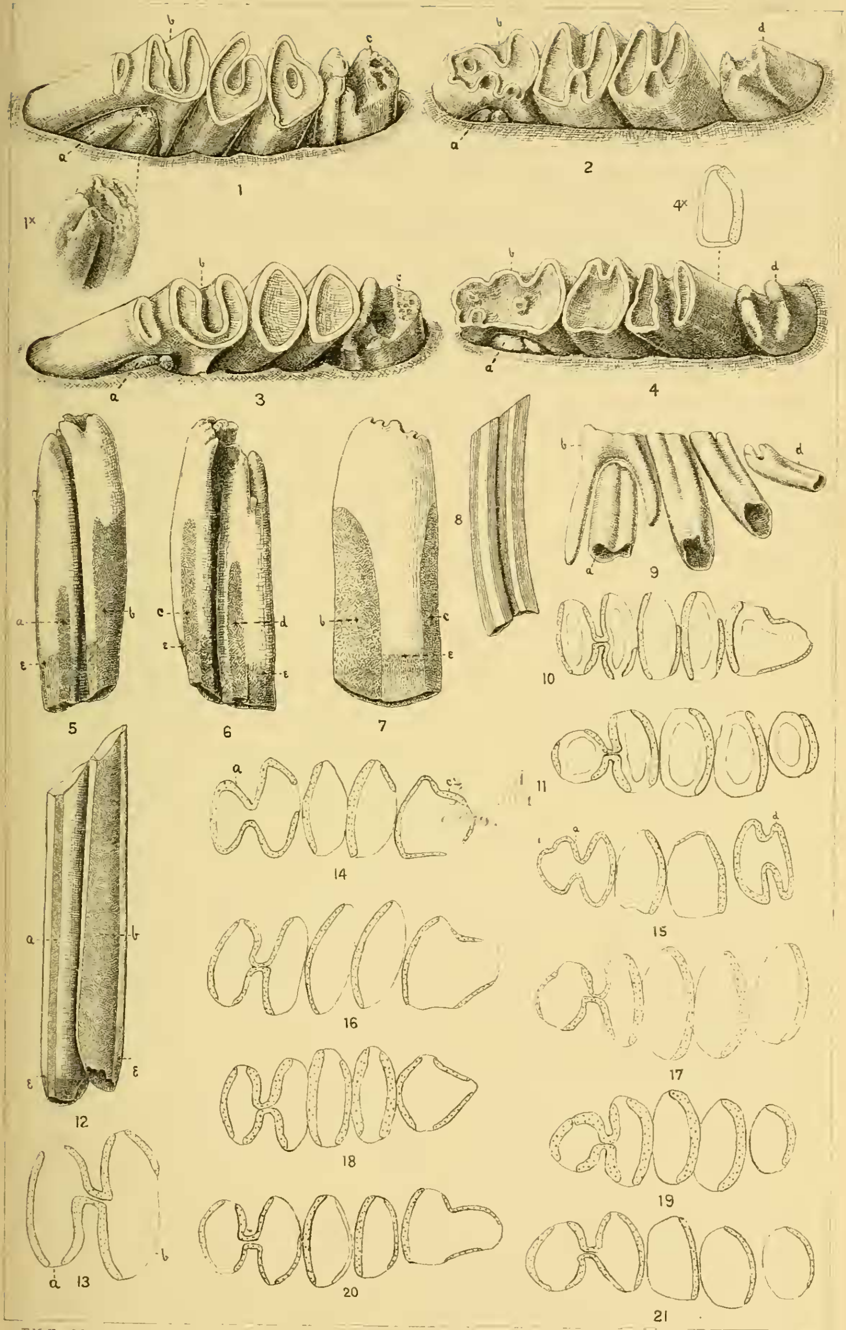
Crowns of molariform series showing permanent enamel pattern.

18. Left upper series.
19. Left lower series.

20 and 21. *Macrogeomys cherriei* im. Santa Clara, Costa Rica. *Type.*

Crowns of molariform series showing permanent enamel pattern.

20. Left upper series.
21. Left lower series.



F. Muller del. Much enlarged B. Meisel photo lith.

1, 2, 5, 6, 7, 12 & 13. HETEROGEOMYS HISPIDUS 3, 4, 9, 18 & 19. GEOMYS BURSARIUS
8. HETEROGEOMYS HETERODUS 10 & 11. ZYGOGEOMYS TRICHOPUS
14, 15, 16 & 17 CRATOGEOMYS CASTANOPS 20 & 21. HETEROGEOMYS CHERRIEI

PLATE 17.

(All natural size.)

Skulls seen from above; vault of cranium cut away, showing floor o brain case.

1. *Heterogeomys torridus.* Motzorongo, Vera Cruz, Mexico
2. *Zygogeomys trichopus.* Nahuatzin, Michoacan, Mexico.
3. *Geomys bursarius.* Portland, North Dakota.
4. *Platygeomys gymnurus.* Zapotlan, Jalisco, Mexico.
5. *Cratogeomys merriami.* Amecameca, Valley of Mexico.

Key to pl. 17.

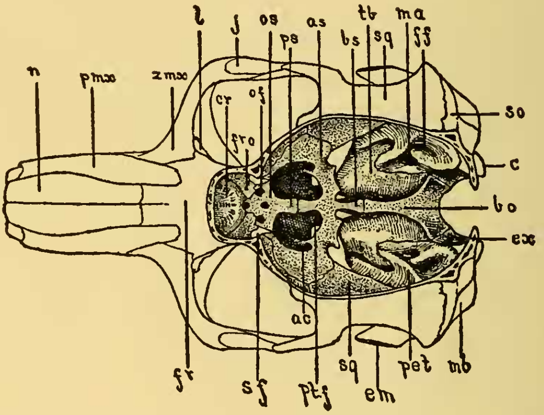
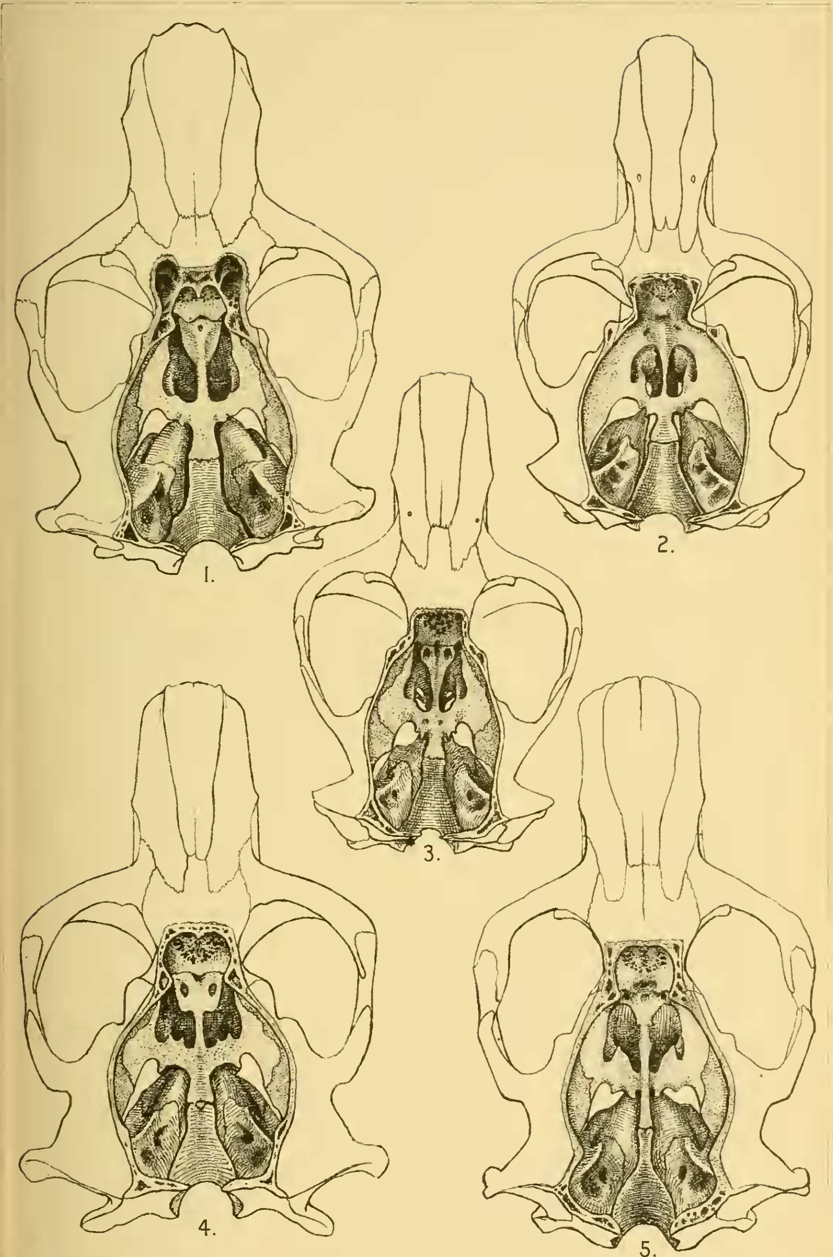


FIG. 9.—Young skull of *Cratogeomys merriami*, vault of cranium cut to show floor of brain case.

ac Anterior opening of alisphenoid can
as Alisphenoid bone.
bo Basioccipital.
bs Basisphenoid.
c Condyle of exoccipital.
cr Cribriform plate of ethmoid.
em External auditory meatus.
ex Exoccipital.
ff Floccular fossa.
fr Frontal.
fro Descending or orbital plate of frontal (the animal is so young that the plates of the two sides have not yet united below).
j Jugal.
l Lachrymal.
ma Meatus auditorius internus.
mb Mastoid bulla.
n Nasal.
of Optic foramen.
os Orbitosphenoid.
pet Petrous part of periotic.
pmx Ascending arm of premaxilla.
ps Presphenoid.
ptf Spheno-pterygoid fossa.
sf Apex of sphenoidal fissure.
so Supraoccipital.
sq Squamosal.
tb Superior face of tympanic or audital bull
zmx Zygomatic root of maxilla.



F. Muller del. B. Meisel, plate

1. Heterogeomys torridus sp. nov. 2. Zygogeomys trichopus sp. nov.
3. Geomys bursarius (Shaw) 4. Platygeomys gymnurus (Merriam)
5 Cratogeomys merriami (Thomas)

PLATE 18.

(All natural size.)

Vertical median longitudinal section of skull (mesethmoid and right half of vomer in place).

1. *Geomys bursarius* ♂. Knoxville, Iowa.
2. *Zygogeomys trichopus* ♀. Nahuatzin, Michoacan, Mexico.
3. *Heterogeomys torridus* ♂. yg. ad. Motzorongo, Vera Cruz, Mexico
4. *Cratogeomys merriami* ♂. Tlalpam, Valley of Mexico.
5. *Platygeomys gymnurus* ♂. Zapotlan, Jalisco, Mexico.

Key to pl. 18.

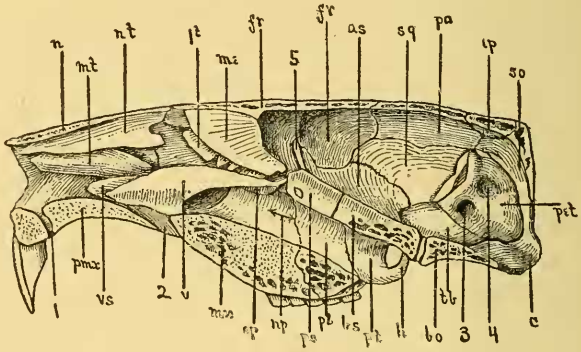
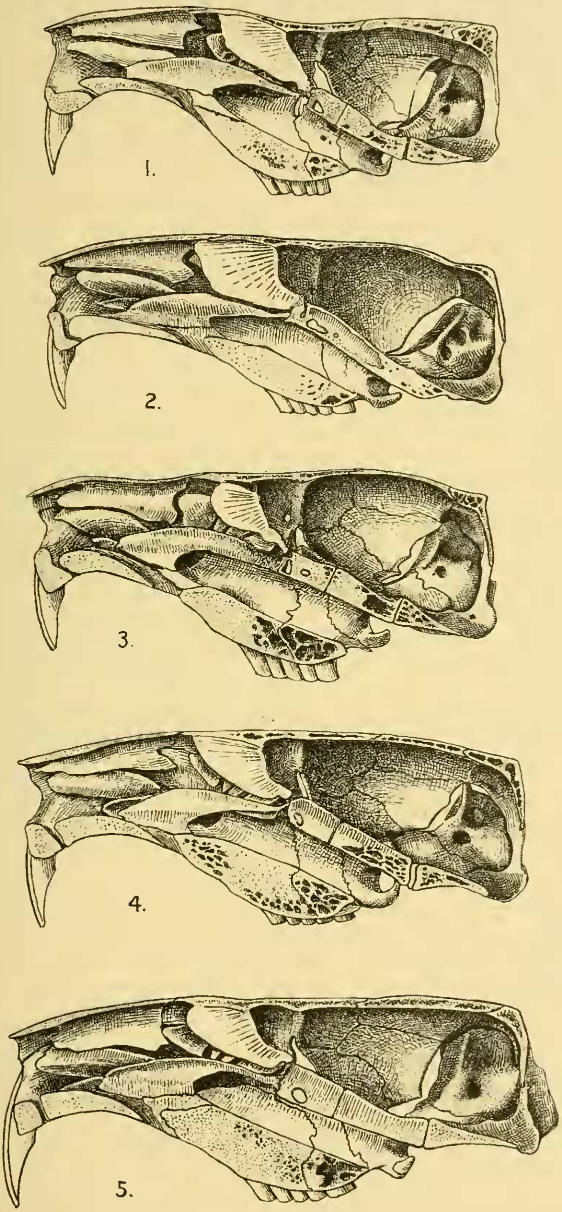


FIG. 7.—Longitudinal vertical median section of skull of *Cratogeomys merriami*, showing interior of brain case and nasal chamber. Vomer and mesethmoid in place.

1 Anterior palatine foramen.
2 Incisive foramen.
3 Meatus auditorius internus.
4 Floccular fossa.
5 Upper part of sphenoidal fissure.
as Alisphenoid.
bo Basioccipital.
bs Basisphenoid.
c Condyle of exoccipital.
fr Frontal.
h Hamular process of pterygoid.
ip Interparietal.
me Mesethmoid plate.
mt Maxillo-turbinal.
mx Maxilla.
n Nasal.
nt Naso-turbinal.
op Lower border of os planum.
pa Parietal.
pet Petrous part of periotic capsule.
pl Palatine.
pmx Premaxilla.
ps Presphenoid.
pt Pterygoid.
so Supraoccipital.
sq Squamosal.
tb Tympanic bulla. (antero-superior part, which alone appears within the brain case.)
v Vomer.
vs Vomerine sheath of maxilla.
1t First endoturbinal (Below and somewhat behind it the anterior ends of the second, third, and fourth endoturbinals may be seen.)



F. Muller, del. B. Meisel, photo lith.

1. GEOMYS BURSARIUS 2. ZYGOGEOMYS TRICHOPUS 3. HETEROGEOMYS TORRIDUS
4. GRATOGEOMYS MERRIAMI 5. PLATYGEOMYS GYMNURUS

PLATE 19.

(All natural size.)

1. *Orthogeomys scalops* ♀ ad. Oaxaca, Mexico (skull from above).
2. *Orthogeomys scalops* ♀ ad. Same specimen (base of cranium).
3–7. Median longitudinal section of nasal chamber (vomer and mesethmoid removed) showing turbinated bones.
3. *Geomys bursarius* ♂. Knoxville, Iowa.
4. *Zygogeomys trichopus* ♀. Nahuatzin, Michoacan, Mexico.
5. *Heterogeomys torridus* ♂. Motzorongo, Mexico.
6. *Cratogeomys merriami* ♂. Tlalpam, Valley of Mexico.
7. *Platygeomys gymnurus* ♂. Zapotlan, Jalisco, Mexico.

Key to pl. 19.

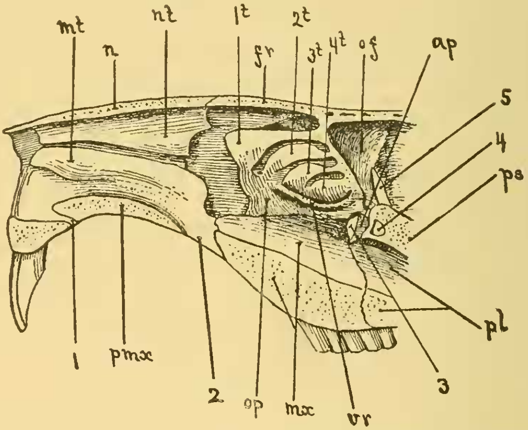
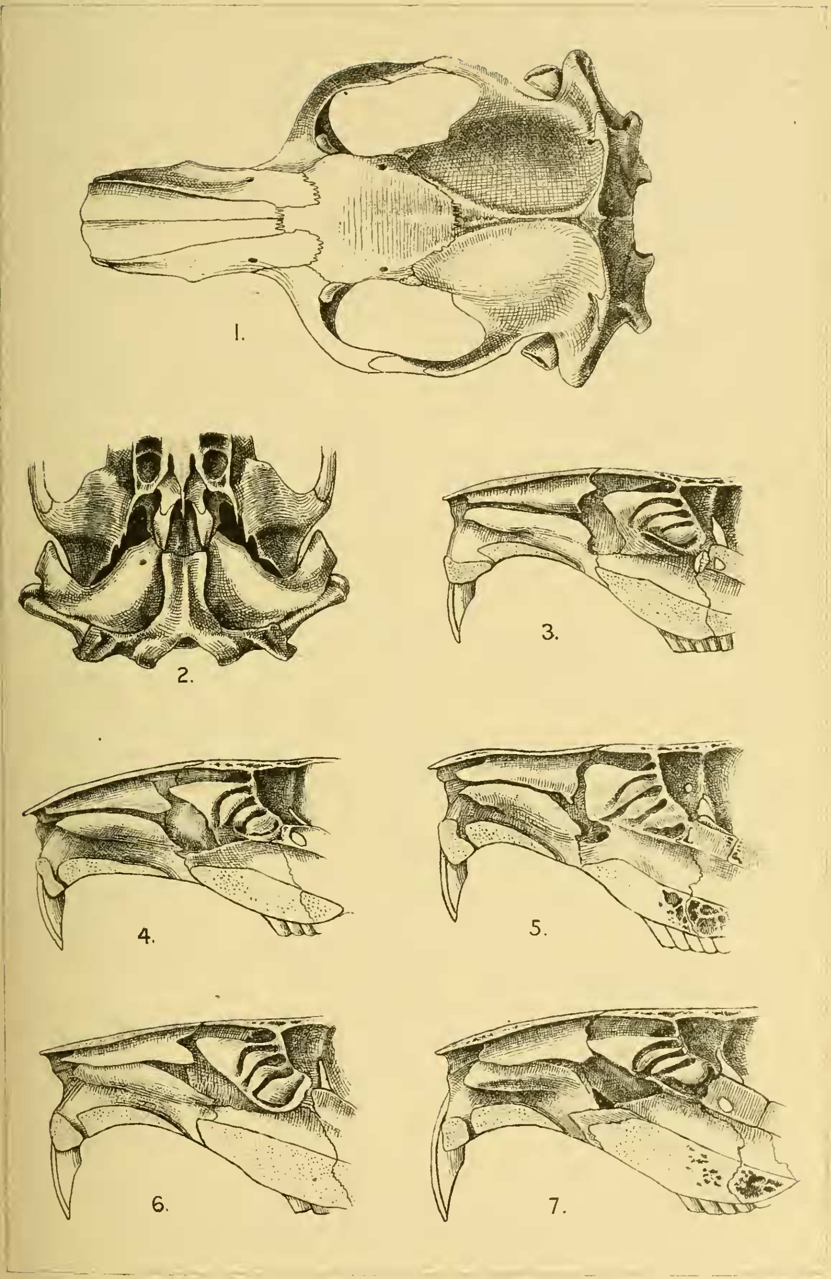


FIG. 10.—Longitudinal vertical median section of front part of skull of *Geomys bursarius*. Mesethmoid and vomer removed to show turbinated bones.

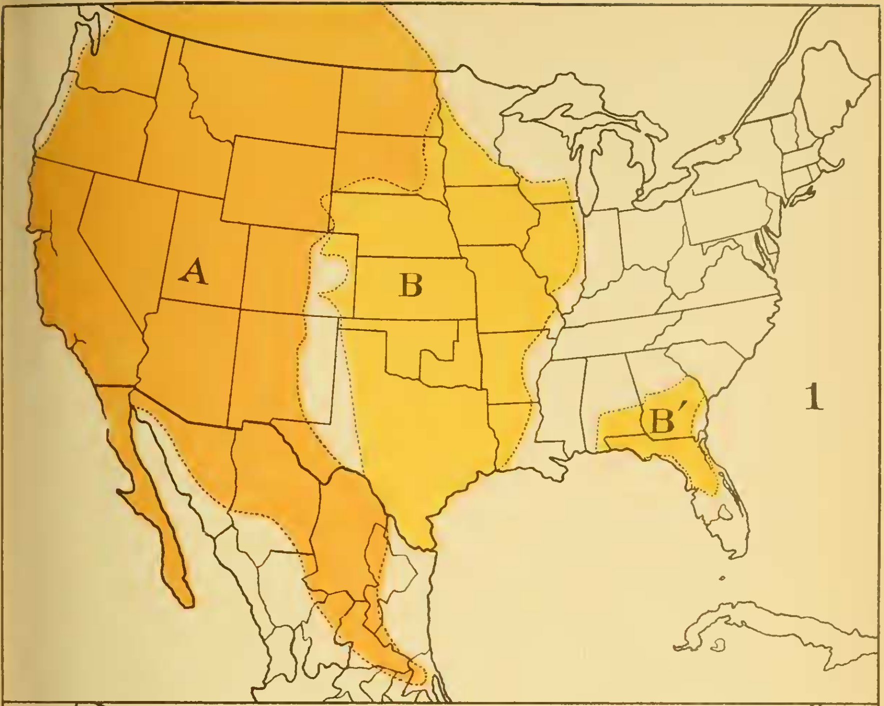
1 Anterior palatine foramen.
2 Incisive foramen.
3 Vacuity in front of presphenoid (present in *Geomys bursarius* and *tuza* only. It is partly overlapped posteriorly by the ascending wing of the vertical plate of the palatine, *ap*.).
4 Presphenoid fenestrum. Present in all species.
5 Upper part of sphenoidal fissure.
1*t* First or superior endoturbinal.
2*t* Second endoturbinal.
3*t* Third endoturbinal.
4*t* Fourth endoturbinal.
ap Ascending wing of vertical plate of palatine.
fr Frontal.
mt Maxillo-turbinal.
mx Maxilla (the upper pointer rests on the maxillary surface of the narial passage, the lower on the sawed body of the bone).
n Nasal.
nt Naso-turbinal.
op Os planum.
pl Palatine (the upper pointer rests on the palatine face of the narial passage, the lower on the sawed horizontal body of the bone).
pmx Premaxilla.
ps Presphenoid.
vr Vomerine ridge of os planum (unites with the lateral wing of the vomer).

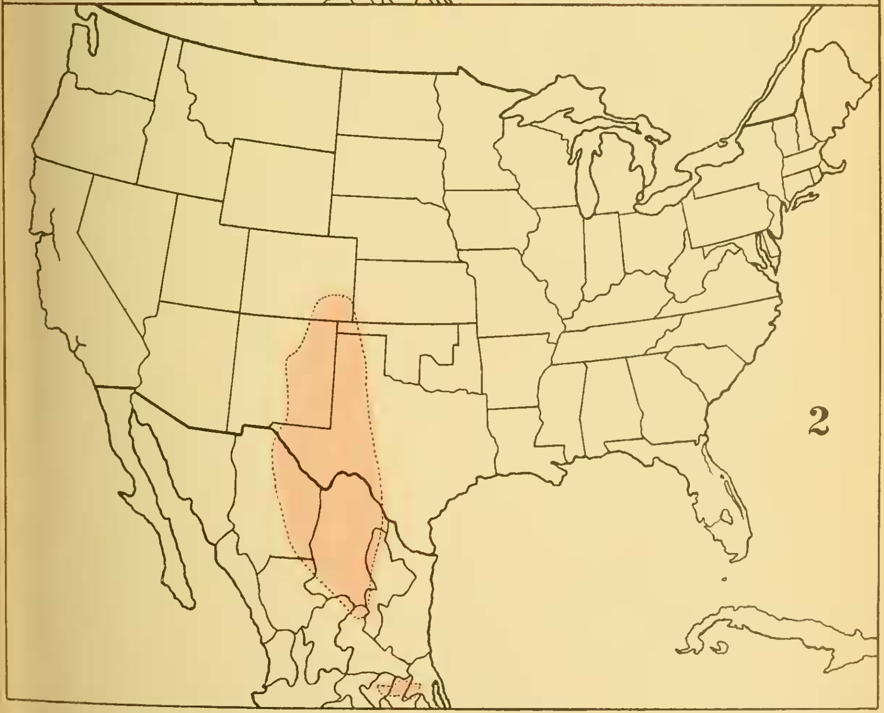
○



F. Muller, del. B. Meisel, photo lith.

1. & 2. ORTHOGEOMYS SCALOPS ♀ 3. GEOMYS BURSARIUS 4. ZYGOGEOMYS TRICHOPUS
5. HETEROGEOMYS TORRIDUS 6. CRATOGEOMYS MERRIAMI
7. PLATYGEOMYS GYMNURUS





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MAP 1. –*A* DISTRIBUTION OF GENUS *THOMOMYS*.
B DISTRIBUTION OF GENUS *GEOMYS* (B = *G. bursarius* group; B′ = *G. tuza* group.)

MAP 2.—DISTRIBUTION OF GENUS *CRATOGEOMYS*.

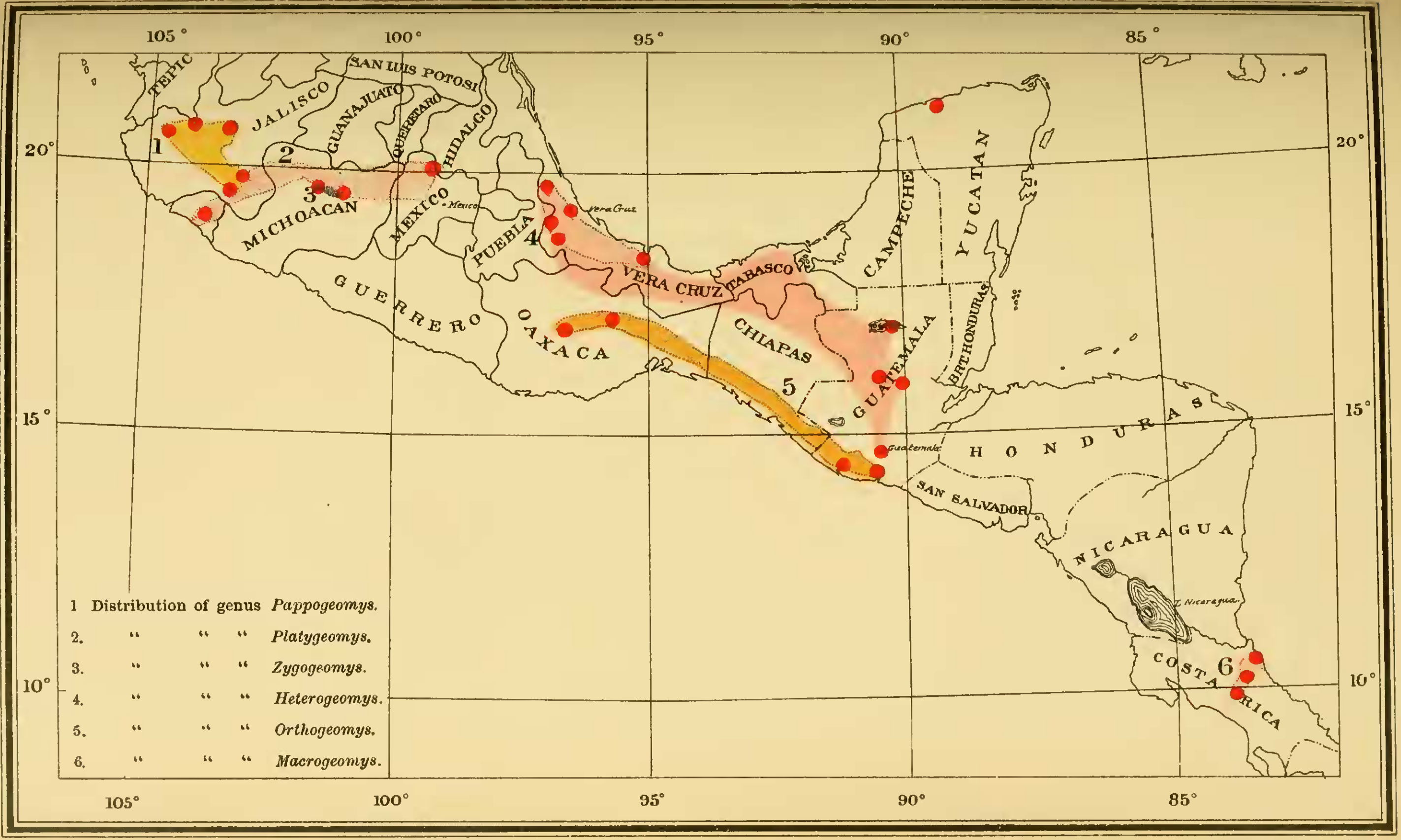

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PLATE XII.

[All double natural size.]

FIGS. 1- 3. *Sorex (Atophyrax) bendirii palmeri.* Oregon City, Oregon. Type. (No. 56898, U. S. Nat. Mus.)

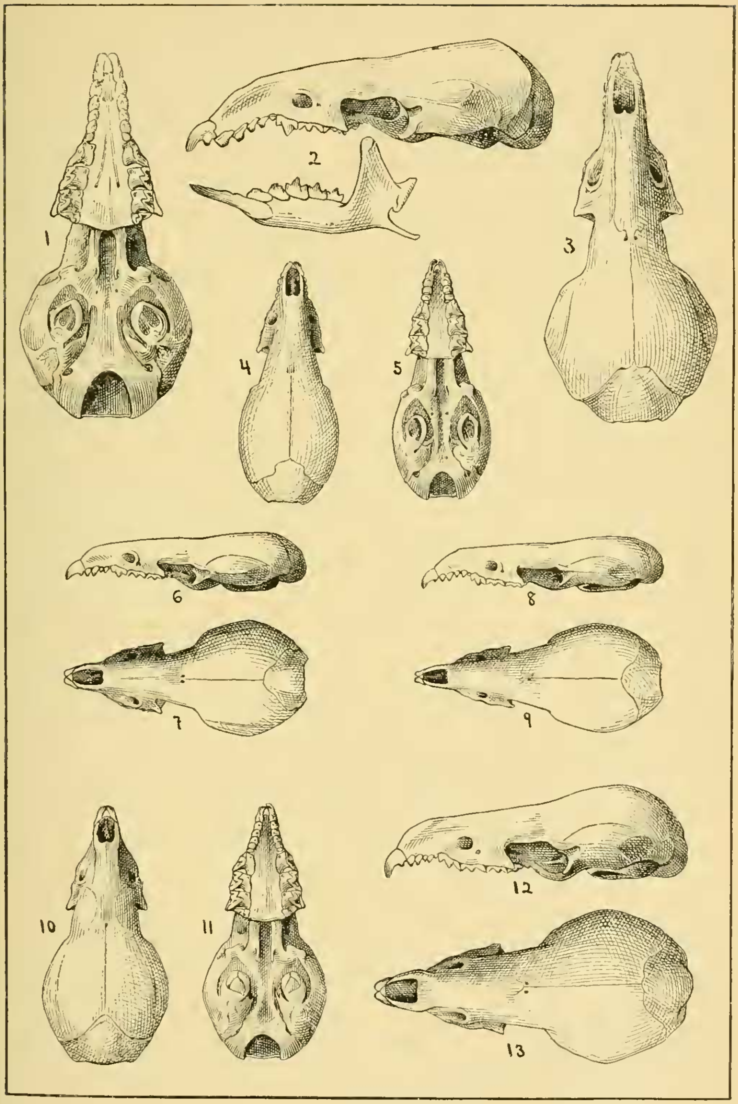
4- 5. *Sorex (Microsorex) hoyi.* Elk River, Minn. (No. 2520, Merriam collection.)

6- 7. *Sorex californicus.* Walnut Creek, Contra Costa County, Calif. (No. 44428, U. S. Nat. Mus.)

8- 9. *Sorex tenellus.* Lone Pine, Owens Valley, California. Type. (No. 32495, U. S. Nat. Mus.)

10–11. *Sorex merriami.* Fort Custer, Mont. Type. (No. 4861, ♀, Merriam collection.)

12–13. *Sorex macrodon.* Orizaba, Vera Cruz, Mexico. Type. (No. 58272, ♂, U. S. Nat. Mus.)



1–3. *Sorex bendirii palmeri.*
4, 5. *S. hoyi.*
6, 7. *S. californicus.*
8, 9. *S. tenellus.*
10, 11. *S. merriami.*
12, 13. *S. macrodon.*